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Episodic Acidification and Associated Fish and Benthic Invertebrate Responses of Four Adirondack Headwater Streams An Interim Report of the Episodic Response Project

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EPISODIC ACIDIFICATION AND ASSOCIATED FISH AND BENTHIC INVERTEBRATE RESPONSES OF FOUR ADIRONDACK HEADWATER STREAMS: AN INTERIM REPORT OF THE EPISODIC RESPONSE PROJECT

by

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16. ABSTRACT

The U.S. EPA Episodic Response Project (ERP) through cooperation with Adirondack Lakes Survey Corporation, Pennsylvania State University, and the U.S. Geological Survey initiated field work in the autumn of 1988 to examine the effects of acidic deposition on aquatic ecosystems. During the first nine months of study, significant results were obtained, thus this interim report was produced.

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ABSTRACT

Four headwater streams located in the Adirondack region of New York State are being intensively studied as part of the EPA-funded Episodic Response Project. The goal of the project initiated in the fall of 1988 is to document the impacts episodic precipitation and snowmelt events have on the chemistry and biology of these systems. Stream sites have been continuously monitored for water quality parameters and intensively studied to determine fish movements and changes in fish population abundance associated with episodes. Significant changes in stream chemistry and associated biological effects were observed in response to certain hydrologic events.

Fish held in bioassay cages in the study streams experienced high mortality during fall episodes, with blacknose dace showing greater sensitivity to the episodic conditions than brook trout. The stream fish populations were exposed to the fall episode and spring snowmelt periods. By spring, the brook trout populations were much smaller, and the blacknose dace were eliminated from the three study streams which experienced the most acidic snowmelt periods. Lowest pH and highest total dissolved aluminum levels in the streams were recorded during spring snowmelt.

This interim report is submitted in fulfillment of Contract No. 815189-01 by the Adirondack Lakes Survey Corporation under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers a period from 15 September 1988 to 30 June 1989.

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1.0 INTRODUCTION

Within the National Acidic Deposition Assessment Program (NAPAP), most research that has examined the effects of acidic deposition on aquatic ecosystems has focused on chronic or long-term acidification. However, a number of studies in the United States, Canada and Europe have revealed that significant acidification and water chemistry changes can occur during high flow periods caused by rainstorms and periods of snowmelt. Further, these studies have indicated that these episodes may have significant effects on fish and other aquatic biota. To address concerns regarding the potential of episodic acidification to impact aquatic ecosystems in the northeastern United States, the U.S. Environmental Protection Agency developed the Episodic Response Project (ERP). The major objectives of the ERP are:

(1) Determine the magnitude, duration and frequency of episodic chemical changes that accompany hydrologic events (both snowmelt and rainstorms) in streams of the United States.

(2) Determine whether episodic chemical changes in streams have long-term impacts on fish populations.

(3) Improve the understanding of the processes and factors that influence the severity of episodic chemical changes in streams and their associated effects on fish populations.

(4) Test and develop episodic chemistry models that can be used to make regional predictions of episodic acidification.

Through the cooperation of the Adirondack Lakes Survey Corporation, Pennsylvania State University and the U.S. Geological Survey, the ERP initiated field work during the autumn of 1988 (Figure 1-1). Field research will continue through June 1990. However, significant results have been obtained during the first two runoff seasons (fall 1988 and spring 1989). So that these results can be included in the NAPAP State of Science and Integrated Assessment reports, each ERP field research group has prepared an interim report (dealing with the first three ERP objectives) that provides a basic presentation of the findings of the first nine months of study. Final reports will be prepared during late 1990 and early 1991 and will include a more in-depth analysis of the ERP data set for the entire study period.

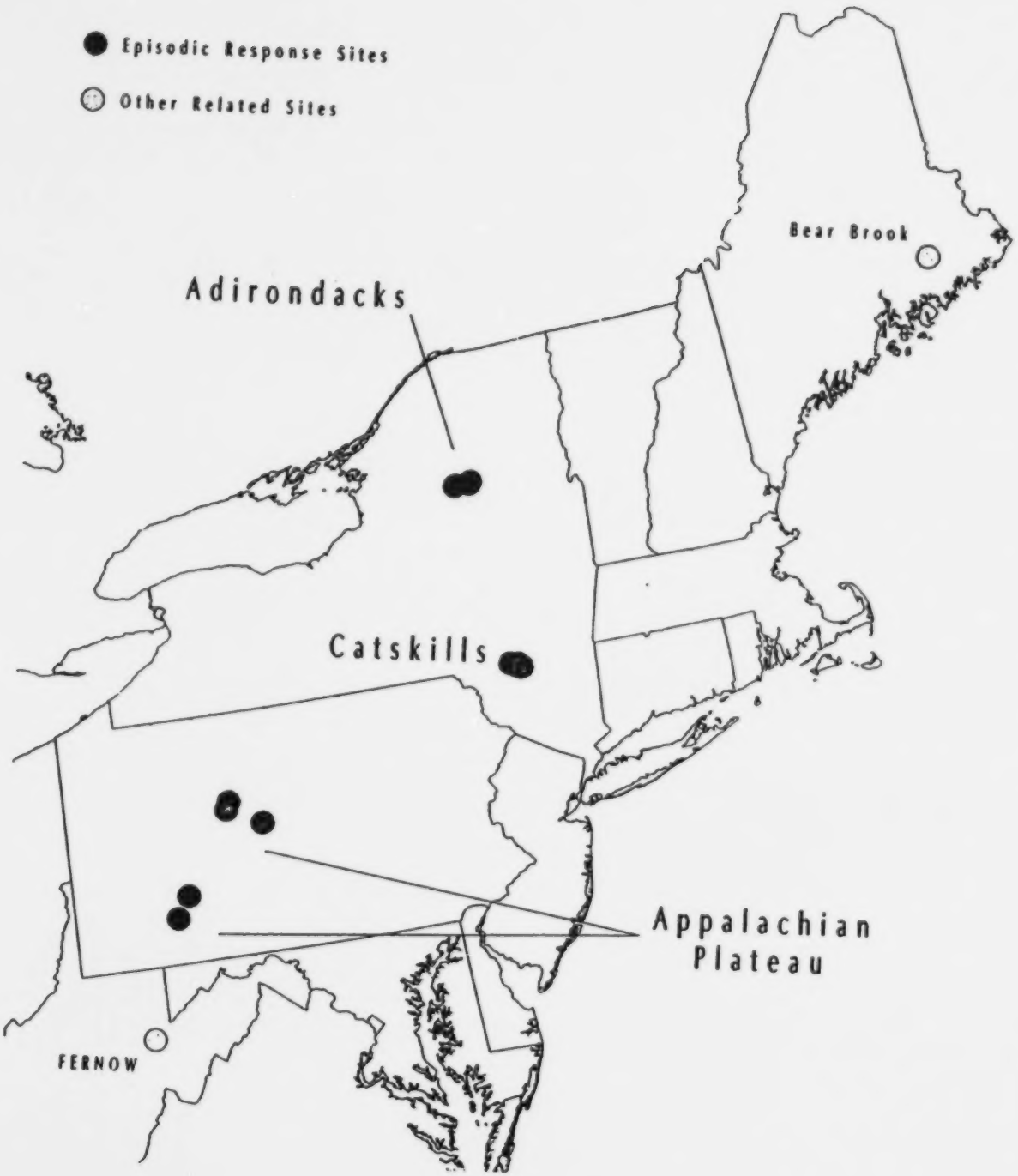


Figure 1-1. Episodic Response Project Site Locations and other related project sites.

1.1 Background

During spring snowmelt and following major precipitation events, stream ecosystems may be affected by episodes of decreased pH and elevated aluminum concentrations. These episodes may be of varying duration and severity. In evaluating the magnitude of biological effects of acidic deposition, it is essential to understand how fish populations react to episodes and if refuge areas with more favorable water quality are utilized.

In the Adirondack region of New York State, research has been conducted documenting the impacts of acidic deposition on aquatic systems. Field studies conducted by Colquhoun et al. (1983a) documented fishless streams which had spring pH levels less than 5.0. A more extensive survey of 200 Adirondack streams indicated that 19 percent of the streams investigated exhibited springtime pH levels less than 5.0 (Colquhoun et al. 1984). This study and others also documented the occurrence of spring pulses of low pH in Adirondack streams (Colquhoun et al. 1981, 1982; Schofield et al. 1985; Driscoll et al. 1987) and summer storms that were associated with acidic episodes equally as acidic as snowmelt episodes.

During episodes, levels of inorganic monomeric aluminum occur which are known to be toxic to fish. Fish held in cages in these streams exhibited high mortalities (Colquhoun et al. 1983b; Johnson et al. 1987). Schofield and Driscoll 1987 conducted extensive fisheries surveys and found no fish or very sparse populations in the streams which Johnson et al. (1987) found to be most toxic. These two studies suggested that fish populations in certain streams in the Adirondack region are restricted by the toxic water quality conditions that occur during episodes. Some streams which formerly had fish are now fishless. These streams exhibited satisfactory water quality during summer low flow, but apparently experienced episodes where water chemistry was toxic to fish (Schofield and Driscoll 1987).

Sensitivity to toxic conditions is dependent on the fish species and the life stage (Baker and Schofield 1982; Johnson et al. 1987 and Mount 1989). When fish are present in a stream with marginal water quality, it is important to know the specific water chemistry characteristics that will cause mortality or movement. Individual fish may elect to move to more favorable habitats during an episode with certain species able to make this change more easily than others. Spatial variability in stream water chemistry occurs in some Adirondack streams. This variability may be the result of ground water upwellings or tributaries of varying water chemistry that may provide a temporary refuge from adverse changes in water quality as a result of snowmelt or storm events.

Fish are known to be able to detect and select favorable pH levels (Johnson and Webster, 1977; Frenette and Dodson, 1984; Schofield, personal communication) in lakes. However, it is not known that stream fish populations react similarly to changes in water chemistry during episodes that result in low pH and high aluminum values.

The Adirondack Episodic Response Project is designed to address the questions relating to fish movement and survival during episodic events in this region of New York State.

1.2 Goal and Objectives

The goal of the Adirondack Episodic Response Project is to determine the effects of episodic precipitation on fish populations and water chemistry in four headwater Adirondack streams.

Specifically, the objectives of this study are:

- To determine the duration, frequency and intensity of episodes, via water chemistry and hydrologic monitoring in four headwater Adirondack streams.

- To determine the frequency of occurrence and characteristics of episodes necessary for the interpretation of fish population response and results from the fish transplant experiments.

- To determine the effects of episodes on brook trout and blacknose dace survival through modified "in situ" cage studies.

- To determine the movements of transplanted fish populations in response to episodes.

- To determine water chemical parameters that correlate with fish movement during episodes.

- To provide additional information that should aid in the interpretation of fish survey data, by demonstrating that stream reaches exhibit chemical conditions during episodes that cause fish avoidance or increased mortality.

- To provide an improved understanding of the mechanisms of fish population response to episodic acidification including those characteristics of episodes that determine the severity of effects on fish population.

1.3 Study Area

1.3.1 Location

The Adirondack region of New York contains some of the oldest rock found in North America. The rock formations are of Precambrian origin (1.1 billion years old) and form a mountainous dome region that is an exposed southern extension of the Canadian shield land mass. The rocks are highly metamorphosed, mainly crystalline in structure, composed of gneiss, granite and basic igneous rocks with mixtures of quartzite and some limestone. The Adirondack area is divided into two physiographic regions, the High Peaks and the Adirondack Highlands. The High Peaks, located in the east central region, reach a maximum elevation of 1630 m at Mount Marcy and are underlain solely by anorthosite, a rock which is highly resistant to erosion. The Adirondack Highlands are composed of less resistant rock types such as granitic gneisses which decrease in elevation towards the south and west until they merge into the surrounding plateau of approximately 460 m. Metasedimentary rocks occur in the valleys and lowlands of the north and northwest.

The Adirondacks have been covered by several continental glaciers which continued to shape the character of the region. Glacial modifications added numerous layers of boulders, cobbles, gravel, sand and basal till to the region. Soils that occur in the Adirondacks have been developing since the retreat of the last ice age, approximately 12,000 years ago, and are generally thin layered and quite acidic in the upper organic-rich horizons. This produces a soil low in available nutrients and consequently low in fertility.

The Adirondacks are characterized by a climate which produces short cool summers and long cold winters. Typical temperatures range between -40°C in January to 28°C during July. Winds are generally from west to east. Annual precipitation amounts range from 100 to 150 cm. During the winter months, as much as 1.2 to 1.5 m of snow pack can accumulate.

The Episodic Response Project study area is located in the southwestern highlands region of the Adirondacks where elevations range from 400 m to 700 m. Four streams located in the Oswegatchie-Black watershed were selected as the primary study locations. This region of the Adirondacks appears to be most sensitive to acidic deposition. The streams selected include: Fly Pond Outlet, Bald Mountain Brook, Buck Creek and Seventh Lake Inlet. All streams are located within a 10 km radius of Eagle Bay, New York (Figure 1-2).

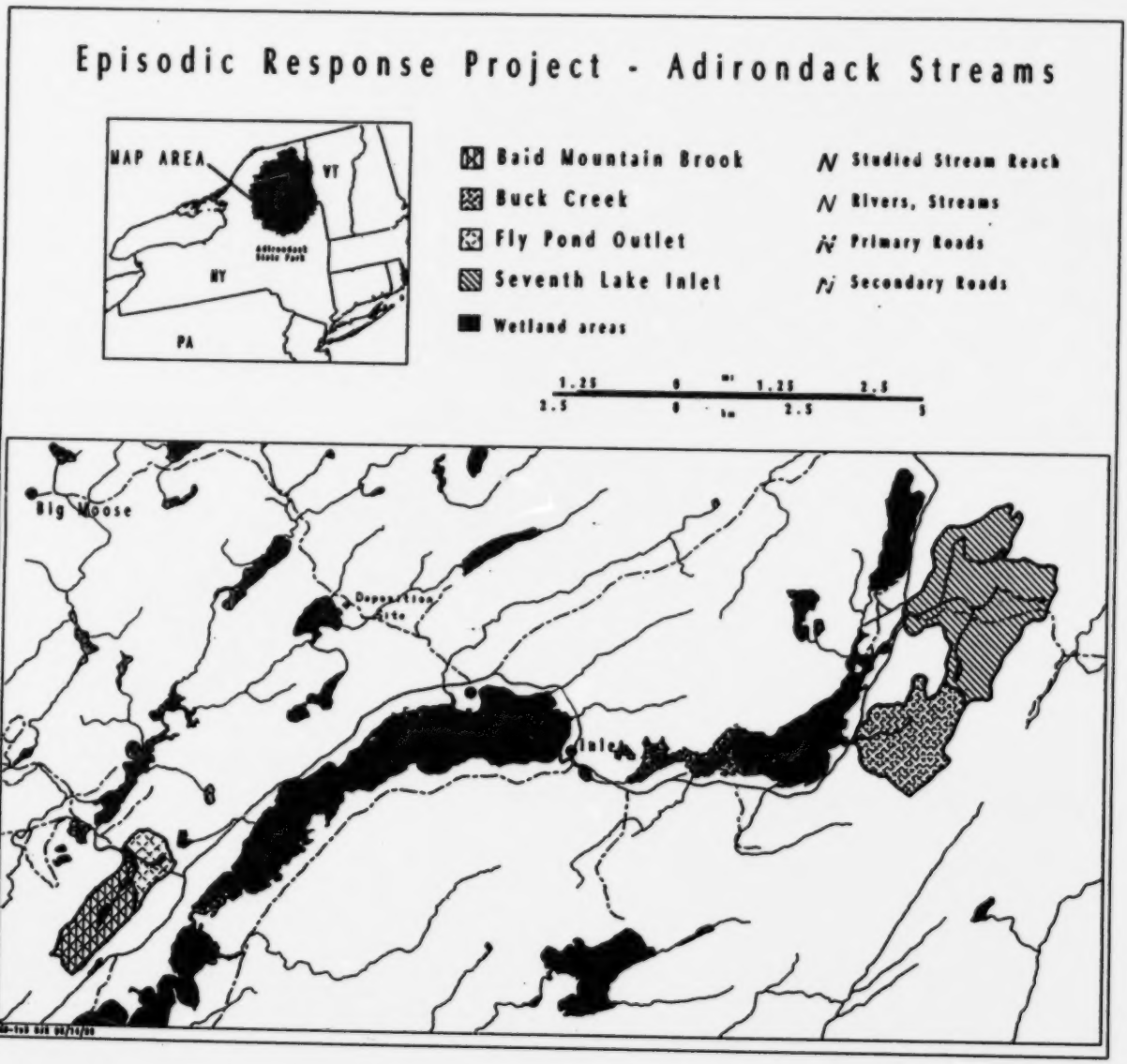


Figure 1-2. Adirondack Episodic Response Project site location.

1.3.2 Site Description and Characteristics

Study site description and characteristics are provided in Table 1-1. Fly Pond Outlet, the control stream, is a circumneutral stream and is the smallest of the four study streams with a watershed area of 1.0 km^2. Seventh Lake Inlet is the largest study stream with a watershed area of approximately 7.0 km^2. Study reaches ranged in length from 143 m (Bald Mountain Brook) to 280 m (Buck Creek). All four streams are headwater streams with physical features characteristic of Adirondack streams that support brook trout. Forest cover types consisting primarily of hard and soft maple, yellow birch, and American beech are interspersed with red spruce, hemlock, balsam fir and white pine are similar for each watershed. No apparent differences in soil types or bedrock substrate exist among the four watersheds. The soil types in these watersheds are predominantly well drained, loamy soils overlaying bedrock and sandy glacial till ranging in depth from 20.3 to 66.0 cm.

2.0 METHODS

2.1 Field Methods

Field methods used in the Adirondack stream investigations are summarized in detail in the Episodic Response Project Field Training and Operations Manual (USEPA 1988a) and the Aquatic Effects Research Program Episodic Response Project Integrated Quality Assurance Plan (USEPA 1986b).

2.1.1 Instrumentation

Instrumentation shelters were constructed at each study site in the fall of 1988. The location of each of these shelters was established near a pool area with a natural control structure that stabilized water conditions to house equipment and facilitate sample collection operations.

Within each instrument shelter, a U.S. Geological Survey (USGS) minimonitor and Druck (model 930/TI) depth transducer were interrogated every 15 seconds by a Campbell (model CR10WP) field computer. The cables and probes for the two instruments passed through separate PVC pipes into deep areas of the control pool. Stream stage data were recorded by the CR10 every 15 minutes. In addition to stage height, specific conductivity, pH and temperature data were recorded every hour. The CR10 was programed to record stream chemistry more frequently during episodes and to trigger the ISCO (model 2700), automated water sampler to collect one-liter samples at specified increments based on changes in stream stage.

TABLE 1-1. STUDY STREAM CHARACTERISTICS

Descriptor	Fly Pond Outlet	Bald Mtn. Brook	Buck Creek	Seventh Lake Inlet
Watershed Area (km^2)	1.0	2.1	3.4	7.0
Surface Area (m^2)	347.0	222.0	509.0	742.0
Study Reach Length (m)	230.0	143.0	280.0	260.0
Maximum Elevation (m)	573.0	587.0	603.8	582.0
Minimum Elevation (m)	563.0	560.0	560.0	565.0
Maximum Width (m)	5.1	6.2	7.8	9.1
Minimum Width (m)	0.3	0.7	0.4	2.2
Average Width (m)	1.6	3.0	3.1	5.0
Maximum Depth (m)	0.4	0.5	0.7	0.7
Average Depth (m)	0.06	0.10	0.10	0.10
Avg Stream Vel (m/s)	0.105	0.085	0.072	0.067
Stream Gradient (m/km)	43.0	189.0	154.0	65.0
Substrate Type (%)				
Bedrock	0.0	0.7	1.2	0.0
Boulder	5.6	17.6	10.1	33.3
Cobble	10.1	23.1	12.5	19.2
Gravel	28.8	44.6	51.2	33.2
Sand	30.4	9.5	19.6	10.2
Silt	18.4	2.1	2.0	1.8
Clay	0.0	0.0	0.0	0.0
Muck	0.6	0.0	0.0	0.0
Detritus	5.7	2.4	3.4	2.3
Instream Cover (%)				
Undercut Bank	4.1	2.6	3.4	1.4
Boulders	8.6	13.2	8.9	18.8
Logs/Trees	3.7	2.2	3.6	2.4
Vegetation/Detritus	6.1	1.7	2.5	3.2
Canopy Cover (%)	97.5	87.5	85.0	82.5
Pool/riffle ratio (%)	31.9	29.3	53.0	37.1
Bank Stability (%)	99.4	95.9	99.2	99.9
Aquatic Vegetation (%)	4.5	2.4	1.7	5.5

All instrumentation was powered by a 12-volt battery that was continuously charged by a solar panel.

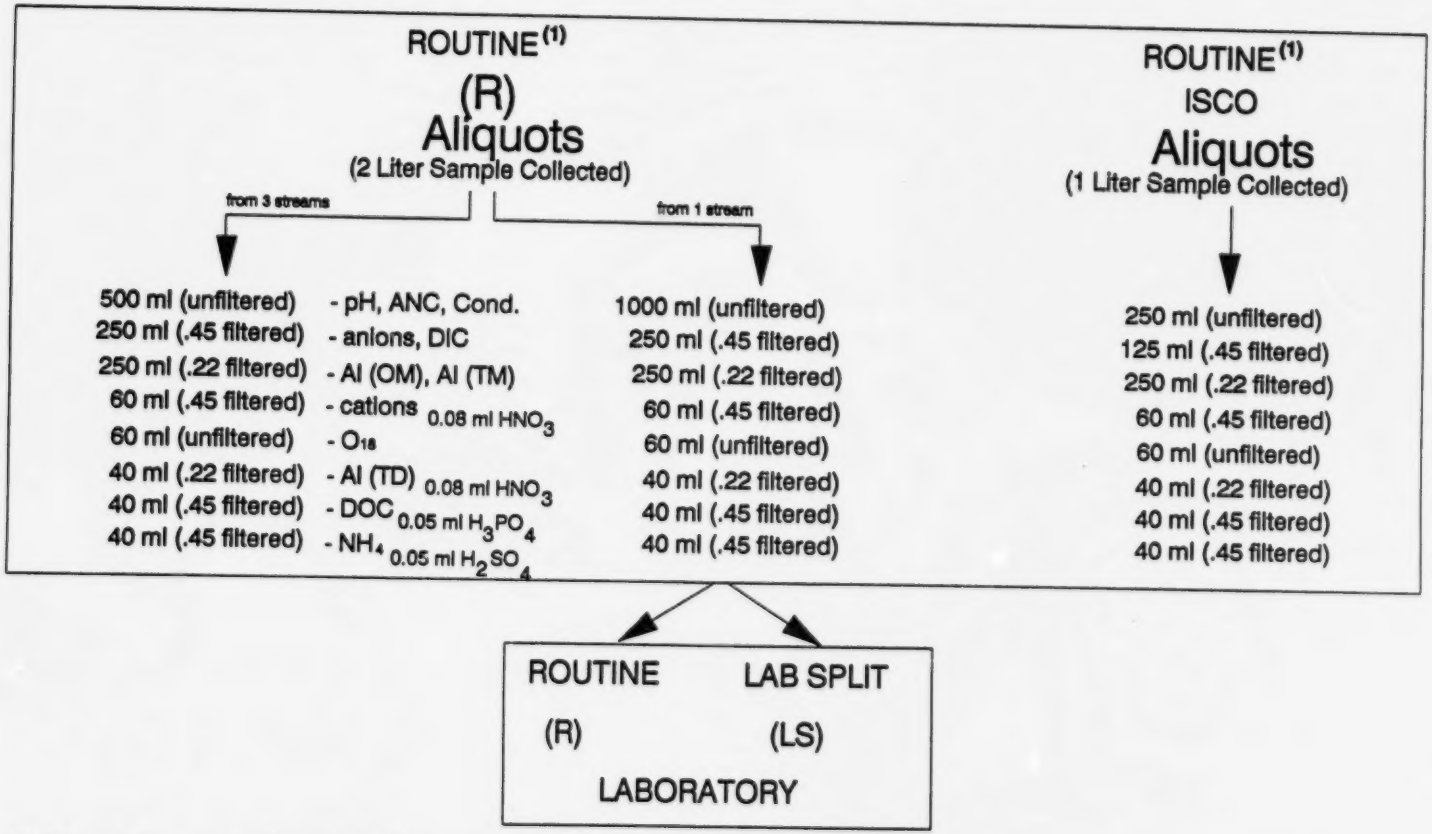
Atmospheric data were collected daily at the Moss Lake wet deposition site with an Aerochem Metrics, Model 301, wet/dry collector. Following precipitation events, the collecting bucket was replaced with a new bucket. The number of lid openings and the changing of buckets were recorded on the rain gage chart and in the site log. The sample bucket was sealed, returned to the field office and weighed. The split sample volume was transferred to a container labeled and stored at 4°C until shipment (monthly) to Battelle-Pacific Northwest Laboratories (PNL) for chemical analysis. Also located at this site was a Belfort recording rain gage (Model 5-780) that was checked following events. Battery operated rain gages were located in the Bald Mountain Brook and Seventh Lake Inlet watersheds. Watershed rain gages were checked weekly.

2.1.2 Water Sample Collections

Routine grab samples were collected weekly from the control pool adjacent to the gage house at mid-channel and mid-depth. During events, additional water samples were collected using the ISCO samplers. The ISCO intake line passed through the same PVC pipe as did the minimonitor probe cables. The ISCO tubes had a plastic strainer located at the end, at about the deepest point in the control pool. The ISCO sample process purged, then rinsed the tygon tube once before water was collected in the sample container. The tygon tubing used to collect ISCO water samples was replaced at six-month intervals in an effort to reduce potential contamination problems.

2.1.2.1 Routine Samples

Generally, routine water samples were returned to the field station, split into filtered aliquots and preserved within a few hours (Figure 2-1). Aliquots were prepared for major cations and anions, dissolved organic carbon (DOC), ammonia, pH, acid neutralizing capacity (ANC), specific conductivity, silica and various aluminum fractions. Oxygen-18 aliquots were obtained from stream water, snow core and wet deposition samples associated with major events during this period. All ISCO samples were treated similar to routine water samples with differences relating to smaller sample volumes. During this reporting period, most ISCO samples were processed at the field station within 24 hours after collection.



(1) All samples were refrigerated after processing and transported in coolers with ice packs.

NOTE: Monomeic aluminum is collected bi-weekly.

Figure 2-1. Field procedures for ERP routine sample aliquots.

2.1.2.2 Special Samples

Additional water samples were collected from the four streams throughout a number of biological sampling and other special studies. During selected bioassays, total dissolved aluminum samples were collected every two or three days from cage locations to determine concentrations occurring in the streams throughout the bioassay experiment. During brook trout radiotelemetry experiments, water samples were collected when fish movement of more than 25 meters occurred within a 24-hour period. Water samples were collected from the beginning and ending locations in order to evaluate differences in stream chemistry associated with changes in location (e.g. ground water seepage for refugia). Only pH, specific conductivity, ANC and total dissolved aluminum were analyzed from telemetry samples. Water samples for these parameters were also collected from five to seven locations within each study reach to determine spatial variability in stream chemistry and to identify potential fish refugia. Waters from source fish streams were also sampled to assess baseline chemistry.

2.1.2.3 Oxygen-18 Samples

Oxygen-18 samples were collected throughout the period beginning in January 1989. The samples were collected from the wet deposition site, snow cores, routine grab and ISCO samples. Oxygen-18 samples were collected in 60 ml Nalgene narrow mouth bottles, labeled, sealed with tape and stored with no air space for future analysis by the University of Waterloo, Environmental Isotope Laboratory, Ontario, Canada.

Twenty-seven selected Oxygen-18 samples from the Bald Mountain Brook and Seventh Lake Inlet study streams, as well as from the snow core sampling sites and wet deposition site, were sent for analysis during May 1989.

2.1.2.4 Quality Assurance/Quality Control

The quality of minimonitor pH, specific conductivity and temperature data was assessed weekly. Electrode accuracy was checked using known concentration quality control check samples (QCCS) 1.0 ml of 0.1 N sulfuric acid per liter deionized water. This produced QCCS equal to approximately 4.03 for pH. For specific conductivity, a KCL (QCCS) of 44.5 uS/cm was used for a check, and 73.9 us/cm used for calibration. If measurements fell outside QCCS warning (and/or control) limits, the meter and probe were recalibrated with known standards. Control charts for pH and specific conductivity were maintained at each gage house. If four successive QCCS

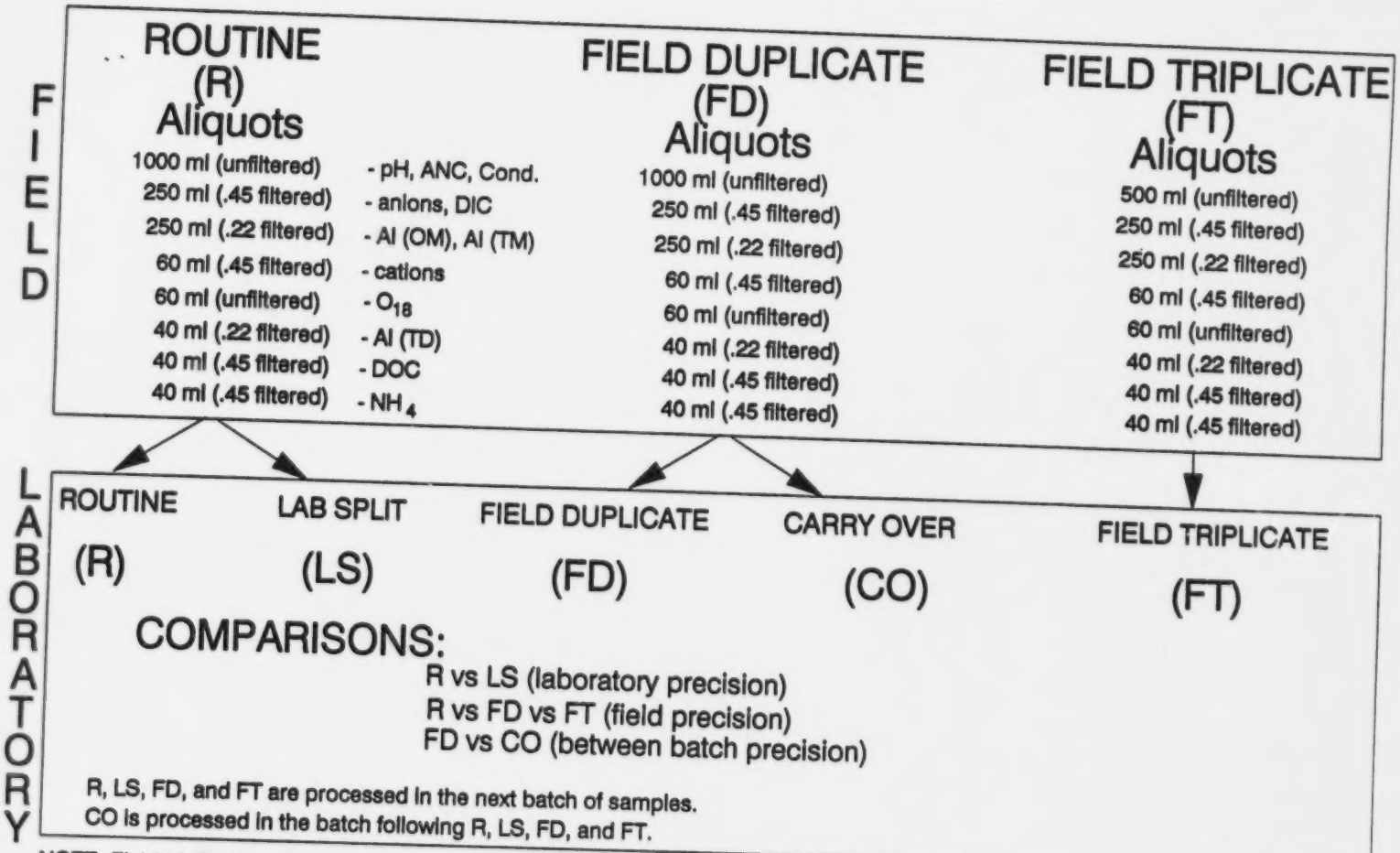
measurements were outside the range equal to one-half the warning limits or if seven QCCS measurements were above or below the mean, the meter/probe was recalibrated. Temperature measurements were considered within control if readings were within 0.5°C of the NBS standard thermometer. Quality of stage data measured within the transducer was assessed by comparing measured stream stage value to actual stage gage readings in the control pool. The transducer offset was readjusted when the readings differed by more than 0.006 m. When any QCCS measurement indicated readings out of control for any parameter, all relevant data between the last QC check and the current evaluations were considered suspect and flagged.

Weekly CR10 data files for each study stream were combined by month then split into a number of files summarizing 15 minute stage, hourly, storm, ISCO samples and daily information. Selected data in these files were flagged for problems associated with the ice/leaves, quality control, probe, minimonitor, CR10, and readings affected by calibration. Flagging operations were conducted by visual inspection of data, checking for problems identified in logs of daily gage house activities and QCCS measurements of pH, specific conductivity and temperature probes. Original data subsets were forwarded to Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV) and EPA Corvallis for verification and validation.

Additional field sampling quality control operations included collection of routine and ISCO sample field blanks to assess potential contamination. These samples were collected, processed and forwarded to the laboratory in the same manner as routine samples. Triplicate samples were collected monthly from a selected stream to assess sampling and analytical variability (Figure 2-2).

2.1.3 Hydrology

Discharge measurements were conducted several times each month beginning mid-January 1989 in each stream using standard USGS gaging techniques (Rantz et al., 1982a and 1982b). Between November 1988 and April 1989, a Marsh-McBirney (model 201D) electromagnetic flow meter was used for all stream section velocity measurements. In an effort to conform more closely to USGS technology, Pygmy current meters fitted with polycarbonate cups were used for velocity measurements in late summer. Discharge measurements, comparing study results and field notes, were used by USGS, Albany to develop rating equations required to estimate discharge from stage data. Fifteen-minute stage data for each stream were converted to 15-minute discharge data.


FIELD
ROUTINE (R) Aliquots
1000 ml (unfiltered) - pH, ANC, Cond.
250 ml (.45 filtered) - anions, DIC
250 ml (.22 filtered) - Al (OM), Al (TM)
60 ml (.45 filtered) - cations
60 ml (unfiltered) - O_{18}
40 ml (.22 filtered) - Al (TD)
40 ml (.45 filtered) - DOC
40 ml (.45 filtered) - NH_4
FIELD DUPLICATE (FD) Aliquots
1000 ml (unfiltered)
250 ml (.45 filtered)
250 ml (.22 filtered)
60 ml (.45 filtered)
60 ml (unfiltered)
40 ml (.22 filtered)
40 ml (.45 filtered)
40 ml (.45 filtered)
FIELD TRIPLICATE (FT) Aliquots
500 ml (unfiltered)
250 ml (.45 filtered)
250 ml (.22 filtered)
60 ml (.45 filtered)
60 ml (unfiltered)
40 ml (.22 filtered)
40 ml (.45 filtered)
40 ml (.45 filtered)
LABORATORY
ROUTINE (R)
LAB SPLIT (LS)
FIELD DUPLICATE (FD)
CARRY OVER (CO)
FIELD TRIPLICATE (FT)
COMPARISONS:
R vs LS (laboratory precision)
R vs FD vs FT (field precision)
FD vs CO (between batch precision)
R, LS, FD, and FT are processed in the next batch of samples.
CO is processed in the batch following R, LS, FD, and FT.

NOTE: Field triplicates are collected monthly - a 2 liter sample is collected for each aliquot.

Figure 2-2. Field procedures for triplicate sample aliquots.

2.1.4 Fish Population Assessments

Fish population estimates were determined in the fall of 1988, April 1989 and June 1989.

An efficiency check of electroshocking gear and procedures was conducted prior to the initiation of population estimates. Efficiency checks consisted of blocking off a 50-100 meter section of the stream, stocking a known number of fin clipped brook trout, *Salvelinus fontinalis* and running three consecutive electroshocker passes as recommended for population estimates.

Population estimates were conducted by field biologists using battery-powered backpack electrofishing gear designed and used by the New York State Department of Environmental Conservation (NYSDEC). Study reaches were blocked off with seines to reduce potential for escape of fish residing within the sampling area. Several holding cages were placed 75 to 100 meters apart within the study reach to retain captured fish and provide appropriate locations for later redistribution of fish into the study reach.

A minimum of three electroshocking passes were conducted on each study stream in order to obtain a population estimate. During each pass, as many fish as possible were removed. Additional passes were required when the "Zippin" removal estimate was not attained on the first three passes (Everhart et al. 1975).

Collected fish were measured and weighed following each pass. Brook trout and blacknose dace, *Rhinichthys atratulus* were examined for marks to determine origin. If fish were unmarked each was given an identifying fin clip. All fish were redistributed throughout the study section.

Each study stream was stocked with additional brook trout and blacknose dace during the fall of 1988 and spring 1989. Initially, study streams were stocked with brook trout at 60 percent of the control stream biomass (weight/area) or 2.0 g/m^2 (based on unpublished NYSDEC data and Haines et al. 1988). Blacknose dace were stocked to a level of 0.4 g/m^2 (Haines et al. 1988). All fish stocked in study streams received an identifying fin clip that denoted origin and stream being stocked.

2.1.5 Fish Movements

2.1.5.1 Fish Traps

Three two-way fish traps were constructed and installed in Fly Pond Outlet and Bald Mountain Brook during the fall of 1988 to assess upstream and downstream fish movement. Fish

traps were constructed with a removable center and funnel screens at either end for periodic cleaning and removal during the winter season. Fish traps were in operation from mid-October to 10 December 1988. Only one fish trap was installed in the lower end of the Fly Pond Outlet study reach during 1988. Four fish traps were in operation by 1 May 1989, at these two streams (Figure 2-3).

By spring of 1989 fish traps were located at the upper and lower ends of the Fly Pond Outlet study reach, and at the downstream limit of the Bald Mountain Brook study reach. Fish movement on the upper end of Bald Mountain Brook was restricted by a natural barrier. An additional fish trap was installed below the confluence of Fly Pond Outlet on Bald Mountain Brook. Positioning of fish traps was designed to monitor daily fish movement in relation to episodes.

Fish traps were checked daily. Fish collected in the traps were checked for fin clips. Fish were then released in the direction they were moving either upstream or downstream.

2.1.5.2 Radiotelemetry

Radiotelemetry experiments were conducted in Fly Pond Outlet and Seventh Lake Inlet during the spring of 1989 for a period of 30 days. Radio transmitters weighing approximately 3.0 g were placed in the stomachs of 16 adult wild brook trout, ranging in size from 150 to 230 mm, collected from nearby source streams. Prior to release each fish was retained in holding cages for approximately 72 hours to assess survival, regurgitation and transmitter function. Upon release the location and frequency assigned to each brook trout was recorded.

Movements of radio tagged brook trout in each stream were recorded daily for the duration of the experiment, or until regurgitation or transmitter failure occurred. When brook trout movement equaled or exceeded 25 meters, a water sample was collected from beginning and ending fish locations. Water samples relating to fish movement were analyzed for pH, ANC, specific conductivity and total dissolved aluminum.

2.1.6 Bioassays

"In situ" bioassays were conducted in each stream. Native brook trout yearlings and blacknose dace were used for the fall 1988 bioassay experiments. Young-of-year native brook trout, adult blacknose dace and hatchery-reared brook trout fry were used for the 1989 spring bioassay experiment.

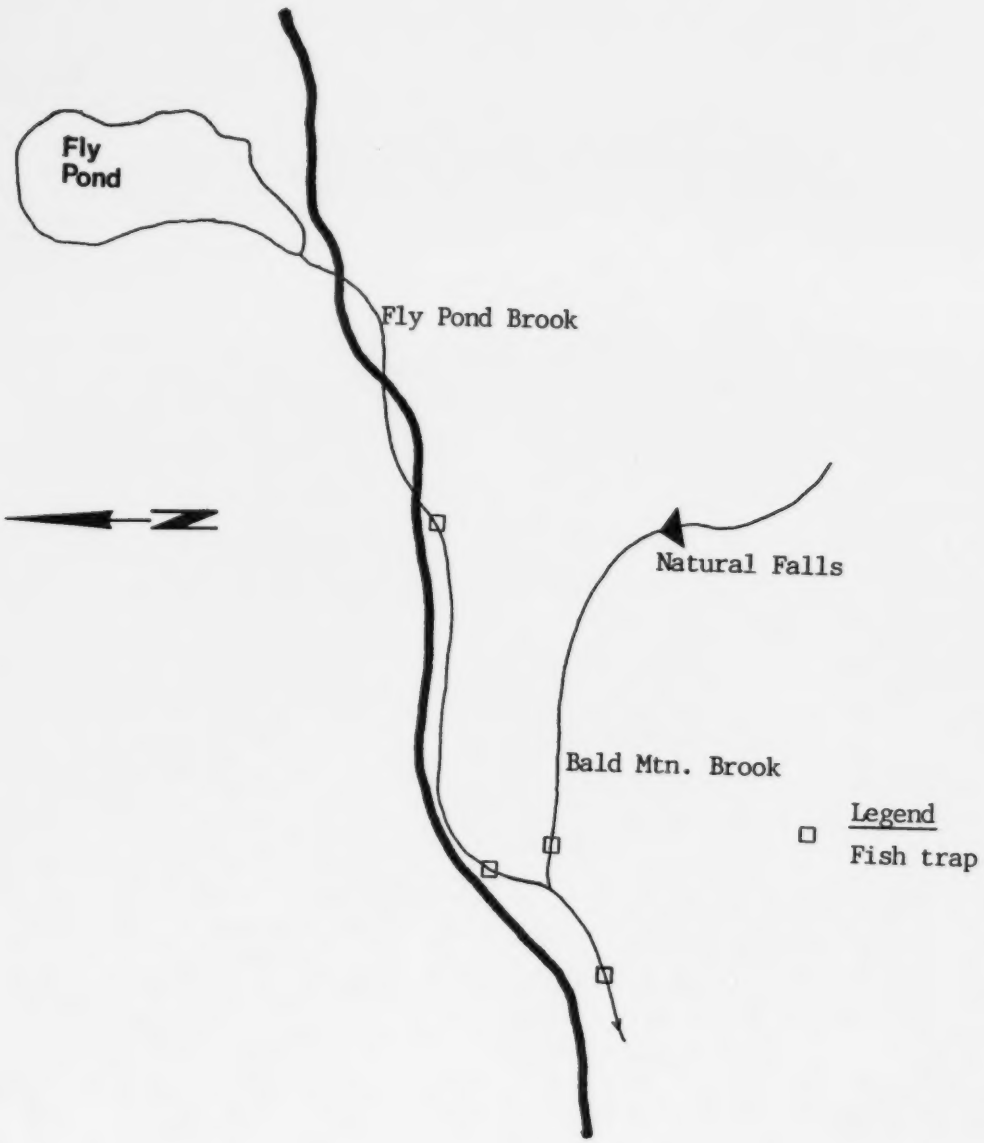


Figure 2-3. Fish trap locations at Fly Pond Outlet and Bald Mountain Brook.

Bioassay experiments were conducted for thirty day periods. Experimental fish were placed in 3.78 liter Nalgene containers each with two 7 x 12 cm openings screened with fiberglass (1.4 mm mesh) to insure adequate water exchange. Containers with fish were placed in wood frame cages with 1/4-inch mesh size plastic screen. Cages with bioassay containers were positioned in pools located in proximity to the stream monitoring equipment.

Twenty fish of each species were divided among the four or five bioassay containers per cage depending on size and weight of fish being used. The length of the largest fish placed in a container did not exceed 1.5 times the length of the smallest fish. To alleviate stress from crowding, total fish weight per container was limited to 20 g or less. Two or three cages with bioassay containers were placed in each stream.

2.1.7 Macroinvertebrates

One macroinvertebrate collection was completed for each study stream in April of 1989. Five individual samples per stream were collected from riffle locations using a standard Surber Sampler with a #30 (0.5 mm) mesh netting. Samples were collected at sites with similar velocities and substrate in each stream. The Surber samples were rinsed, transferred to bottles, labeled and preserved in 70 percent ethanol for sorting and identification. Sample locations and sample sequence were recorded. Taxa were identified using identification keys: Edmonds, Jensen and Berner (1976), Wiggins (1977), Pennak (1978) and Merritt and Cummings (1978).

2.1.8 Snow Core Sampling

Snow core transects consisting of five ten-meter square quadrats 30 meters apart were established along an elevation contour within Bald Mountain Brook and Seventh Lake Inlet watersheds. Snow cores were collected using a graduated Adirondack-type snow tube (7.6 cm diameter, by 152.4 cm long) A specially constructed stainless steel serrated cutting head allowed penetration through ice layers in the snow pack.

Composite snow cores were collected weekly from each quadrat. Snow depth was recorded each time a sample was collected. A composite sample from each transect was returned to the field laboratory, melted and weighed to obtain water equivalency. The sample was filtered and aliquots were prepared for analysis of major cations, anions, DOC, ammonia, pH, ANC, specific conductivity, silica and total dissolved aluminum.

2.2 Laboratory

All water samples collected for the Episodic Response Project were analyzed in the Adirondack Lakes Survey Corporation laboratory (ALSC) located at the Department of Environmental Conservation Headquarters in Ray Brook, NY.

From November 1988 through June 1989, the University of Virginia Laboratory was contracted to perform analyses of eleven parameters for the ALSC laboratory. This arrangement was entered into to provide timely analyses of key chemical parameters while the ALSC laboratory operations were coming on line with appropriate staff and equipment. In addition, duplicate analyses were performed on a total of 47 samples. Statistical analysis of the results indicated no significant difference between the two laboratory with the exception of chloride (Table 2-1). ALSC laboratory results are used in this report.

2.2.1 Sample Handling

Three types of field samples were received and processed in the laboratory including routine, ISCO, and snow core samples. Upon receipt, samples were verified against the chain-of-custody record to insure that each sample was properly handled and labeled. Each sample was assigned a laboratory identification number and was refrigerated at 4°C. Priority for sample analyses was based on chemical parameter holding times.

Weekly, a sample split was conducted on one of the four study streams. To accomplish this, an additional 500 ml sample was collected so that an adequate volume was available to be analyzed for pH, ANC and specific conductivity. Sample splits conducted for other chemical parameters were analyzed using the standard volume collected for normal routine samples.

If the relative percent difference (RPD) result was greater than the EPA established limit, the samples were reanalyzed. Snow core samples were handled in the same manner as routine and ISCO samples.

2.2.2 Sample Analysis

A total of 17 parameters were analyzed. Instrumentation and methodology (Table 2-2) are detailed in the EPA manuals (1979),(1982,) (1984a), (1984b); Standard Methods (1985) and ALSC Laboratory Operating Procedures Manual (1986).

TABLE 2-1. RESULTS OF PAIRED T TEST FOR ALSC AND UNIVERSITY OF VIRGINIA DUPLICATE SAMPLES

Parameter	Number	Prob>|T|	R2
Lab pH	47	0.0001	0.995
ANC	47	0.0001	0.996
Specific Conductivity	47	0.0001	0.998
Cl	47	0.5165	0.996
NO3	47	0.0001	0.992
SO4	47	0.0001	0.999
Na	47	0.0100	0.987
K	47	0.0001	0.938
Ca	47	0.0001	0.993
Mg	47	0.0011	0.990

TABLE 2-2. ANALYTICAL METHODS USED IN THE ADIRONDACK LAKES SURVEY CORPORATION LABORATORY

PARAMETER	INSTRUMENTATION	METHOD	METHOD #	REF
pH (Lab & A.E.)	Orion 811 pH/millivolt meter	Potentiometric	150.1	D
ANC	Orion 811 pH/millivolt meter	Titrimetric-Gran Plot	--	B
Aluminum (Total Dissolved)	Atomic Absorption Spectrophotometer	Atomic Absorption-Furnace	202.2	C
Aluminum, Monomeric (TOTAL & ORGANIC)	Milton Roy Spectronic 1201	Driscoll Chromatographic Method	--	-
Ammonium	Technicon Autoanalyzer I	Colorimetric-Automated Phenate	350.1	D
Calcium	Atomic Absorption Spectrophotometer	AA-Direct Aspiration	215.1	C
Chloride	Dionex 2110i Ion Chromatograph	Ion Chromatography	300.0	F
DIC	Dohrmann DC-80 Carbon Analyzer	Infrared Detection	415.2	E
DOC	Dohrmann DC-80 Carbon Analyzer	Oxidation-Infrared Detection	415.2	E
Magnesium	Atomic Absorption Spectrophotometer	AA-Direct Aspiration	242.1	C
Nitrate	Dionex 2110i Ion Chromatograph	Ion Chromatography	300.0	F
Potassium	Atomic Absorption Spectrophotometer	AA-Direct Aspiration	258.1	C
Silica	Technicon Autoanalyzer I	Colorimetric-Molybdate Reactive	425E	A
Sodium	Atomic Absorption Spectrophotometer	AA-Direct Aspiration	273.1	C
Specific Conductivity	YSI 31 Conductivity Bridge	Wheatstone Bridge	205	A
Sulfate	Dionex 2110i Ion Chromatograph	Ion Chromatography	300.0	F

A - Standard Methods for the Examination of Water and Wastewater. 1985. APHA, 16th edition Washington D.C
B - Gran, G. 1952. Analysis, 77:661-671
C - U.S. EPA 1979. Methods for Chemical Analysis of Water and Wastes. U.S. EPA Cincinnati, OH.
D - U.S. EPA 1984. National Surface Water Survey Methods Manual. U.S. EPA, Las Vegas Nevada.
E - U.S. EPA 1982. Method 415.2 Technical Addition to Methods for Chemical Analysis of Water and Wastes EPA-600-4-82-055. US EPA, Cincinnati, OH.
F - U.S. EPA 1984. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0 EMSL. Cincinnati, OH.

Parameters were analyzed within recommended holding times in accordance with the ERP QA plan, established by EPA (1987 section 7.4.1.3). In some cases, ERP holding times were more stringent than EPA recommendations (i.e. metals). Major cations (Ca, Mg, Na, K) and total dissolved aluminum were analyzed in duplicate. If duplicate values were within ten percent of each other, they were averaged. If the difference was greater than ten percent, a third aliquot would be analyzed and three values averaged to reduce the possibility of analytical error. Laboratory quality control check samples (QCCS) were analyzed for all parameters at the beginning of analysis and at least every tenth sample. When a QCCS was outside control limits established by EMSL-LV, all previous samples in the batch were reanalyzed. A laboratory audit of ALSC laboratory procedures was conducted by EPA staff in May 1989. The results of this audit indicated full compliance with EPA laboratory protocols.

Concentration values were calculated from a linear regression analysis, except for pH and specific conductivity. Specific conductivity and pH were obtained from calibrated meters. ANC was calculated using Grans plot titration. The results of analyses were verified and entered into the ALSC/ERP data base.

2.2.3 Quality Assurance/Quality Control

The quality assurance and quality control program (QA/QC) used by the ALSC laboratory was designed in accordance with standard laboratory QA/QC operations. The QA/QC operations for this project were designed to provide high quality data that were precise, accurate and complete. To obtain high quality data, a number of activities were implemented that provided continuous quality assurance and quality control checks from the point of sample collection through sample analysis.

Chain-of-custody forms were designed to follow samples from collection to receipt at the laboratory. Quality control checks involving QCCS, laboratory blanks, field blanks, duplicate analyses, triplicate analyses, co-located sample splits and various audits were a routine part of laboratory operations during this period of investigation.

2.2.3.1 Field Blanks

Samples of reagent water that met American Society for Testing and Materials (ASTM) Type II specifications (ASTM 1984) were used for field blanks. Field blank samples were taken to the field, collected in an appropriate container and processed as routine water samples. Field blanks were used

to monitor background contamination due to sample collection and processing. One field blank was processed each day a water sample was taken.

2.2.3.2 Laboratory Blanks/QCCS

As part of the QA/QC procedure, the analysis of laboratory blanks and quality control check samples (QCCS) were conducted. After instrument calibration and analysis of QCCS samples, a laboratory blank was prepared from reagent grade water and analyzed every twentieth sample. Warning limits were set at two-thirds the analytical detection limit and control limits were set at the analytical detection limit proposed by EPA. Analysis of laboratory blanks for anions indicated that some results were outside warning and control limits.

A QCCS of a known concentration was prepared independently from calibration standards (i.e. a different stock solution). Both high and low level QCCS were prepared daily and analyzed immediately following calibration of instruments, after every tenth sample, and after all samples were analyzed. Low level QCCS samples were prepared at concentrations three to four times the required analytical detection limit for that parameter. Control limits were equal to the analytical detection limits established by EPA. Warning limits were equal to plus or minus two-thirds the analytical detection limit. Warning and control limits for high-level check samples were equal to plus or minus two and three times the operational objective for precision established by EPA. Based on the results of the QCCS parameter analysis, those parameters exceeding control limits were reanalyzed.

2.2.3.3 Triplicates

Field triplicates were collected monthly on a rotation basis. The field triplicate procedure included a routine, duplicate and a triplicate sample. The laboratory split was taken from the routine sample. The carry over sample was taken from the field duplicate and analyzed with the next batch of samples to assess within batch precision. The results of field duplicate analyses were compared to identify sample processing problems.

2.2.3.4 Co-Located Samples

During ice-free conditions, the ALSC was responsible for collecting and shipping a bulk two liter co-located sample on a quarterly basis. These samples were shipped within 24 hours of collection to each of the ERP regional laboratories for processing and analysis. Results of these analyses were

reported to EMSL-LV and used to compare results among the participating laboratories.

2.2.3.5 Audit Samples

Synthetic audits consisting of five aliquots of three concentrations were prepared monthly at EMSL-LV for ERP laboratories. EMSL-LV was responsible for the preparation, shipment and verification of these samples. The ALSC laboratory analyzed the samples within the recommended seven day period when possible. One aliquot was analyzed for pH, ANC, dissolved inorganic carbon (DIC), and specific conductivity. Two aliquots were analyzed for cations and anions, including silica, and two synthetic samples were used for the analysis of DOC, ammonium and aluminum.

The ALSC laboratory participated in the international round robin network administered by the National Water Research Institute (NWRI) in Burlington, Ontario. Ten evaluation samples were provided as part of the Long Range Transboundary Air Pollution Program (LRTAP).

Field natural audits were collected by EMSL-LV from waters with similar water chemistry to those waters being sampled. Natural audit samples were filtered, sterilized and allowed to stabilize for a designated period of time at EMSL-LV before being shipped to ALSC for analysis.

Once the field natural audits were received, they were sent to the field and were processed as a routine or ISCO sample. The samples were returned to the ALSC laboratory for routine sample analysis and the results were forwarded to EMSL-LV for evaluation.

2.2.3.6 Container Preparation

Six containers of various sizes were prepared in the laboratory for field use. These containers were filled with deionized water for a 2[illegible] hour period and conductivity was measured for ten percent of the containers. If conductivity exceeded the established Data Quality Objective (DQO) of 2.0 uS/cm, the batch of containers was rewashed and retested.

2.3 Data Management

2.3.1 Data Management System

Data base design, including form development for the Episodic Response Project, were the primary responsibility of EMSL-LV. Some modifications were incorporated by ALSC staff to facilitate on-site data operations.

A total of 25 standardized data forms were used. Completed forms were forwarded to data operations staff for validation and verification. Raw data were entered into the ERP data base and verified. Verified data were forwarded to EPA for inclusion into the centralized data base. All data were backed up immediately following data entry and stored in accordance with recommended procedures established by EMSL-LV. Numerous in-house programs were designed to facilitate data entry, minimize data transcription, analyze data and produce outputs for reports.

3.0 RESULTS

3.1 Deposition

3.1.1 Wet Deposition

Precipitation data from rain gages located at the Moss Lake wet deposition site and from Bald Mountain Brook and Seventh Lake Inlet watersheds indicated that rainfall from individual events varied considerably within the study areas. The Moss Lake wet deposition site was operational by mid-December 1988 and rain gages were installed at the other two sites by January 1989. Monthly rainfall amounts at Moss Lake ranged from 54.8 mm to 135.6 mm (Table 3-1). The total precipitation recorded from mid-December 1988 to 30 June 1989 at Moss Lake was 564.7 mm. The greatest amount of precipitation recorded for a 24-hour period was 22.9 mm. Monthly rainfall amounts at the Bald Mountain Brook site ranged from 41.0 mm to 136.0 mm; and Seventh Lake Inlet, 49.0 mm to 137.0 mm.

During the period, December 1988 to 30 June 1989, thirty-six rain, thirty-five snow, and fourteen mixed storm events occurred. Major precipitation events occurred in November 1988 and during March, April and May 1989.

Chemical analyses of the precipitation samples were completed by Batelle-PNL (Figures 3-1 through 3-5). Event based amounts of wet deposition of anions and cations are shown in Figures 3-1 and 3-2. Maximum values for individual events were approximately 117.0 mg/m^2 SO_4; 77.0 mg/m^2 NO_3; 10.0 mg/m^2 Cl; 2.4 mg/m^2 H; 10.0 mg/m^2 NH_4; 1.3 mg/m^2 Na; 13.0 mg/m^2 K; 6.0 mg/m^2 Ca; and 0.9 mg/m^2 Mg.

The mean volume-weighted concentration of the major ions measured in the precipitation during the study period were as follows: 40.2 ueq/l SO_4; 32.8 ueq/l NO_3; 10.8 ueq/l Cl; 51.5 ueq/l H^+; 14.5 ueq/l NH_4; 1.5 ueq/l Na; 4.5 ueq/l K;

TABLE 3-1. DAILY AND TYPE PRECIPITATION (mm) RECORDED AT MOSS LAKE WET DEPOSITION SITE DECEMBER 1988 THROUGH JUNE 1989

DAY	DEC	JAN	FEB	MAR	APR	MAY	JUN
1			0.51 S	2.79 S	2.79 M		0.25 R
2		2.79 S	3.30 M	0.25 S		22.86 R	6.35 R
3		3.81 S	2.03 M	1.02 S	3.30 R	10.16 R	
4				6.35 M	11.43 R		5.08 R
5			0.51 S	6.35 M	4.32 R	2.28 R	
6			3.81 S		8.12 R	19.30 R	3.30 R
7		0.76 S	5.08 S		14.99 S	2.54 R	
8		5.58 M	2.28 S			2.79 R	
9		5.84 S	1.27 S		0.51 S		
10			0.76 S		1.27 S		18.03 R
11			3.04 S	2.28 S		17.52 R	3.56 R
12		2.28 S	4.06 S	2.03 S		6.10 R	
13			0.76 S		2.79 M	6.60 R	3.04 R
14			6.60 M				3.81 R
15	0.76	8.89 M	4.06 S	1.52 R	0.76 M		1.27 R
16	11.94 S	1.27 S	0.76 S	0.51 M			3.81 R
17	0.51 S	4.57 S	0.51 M	2.79 S	2.03 R		6.86 R
18		2.03 S		18.54 R			1.27 R
19		2.79 S					
20		10.16 S	0.25 S	1.02 S	0.76 M	5.58 R	
21	1.52 R	0.51 S	14.99 R	5.33 S			
22			0.51 R				
23	0.76 S						
24	10.16 S			3.30 R		18.28 R	19.56 R
25	9.40 S			4.06 R		3.81 R	
26	0.76 S	11.43 M				6.10 R	
27	1.27 S	8.89 M	0.51 S		0.25 R	1.52 R	
28	13.72 S		1.27 S	1.27 R		2.54 R	6.60 R
29	1.27 S			4.57 R			
30	1.78 S	5.58 R		17.78 R	1.52 R	1.27 R	
31	3.04 S	1.02 M		17.78 R		6.35 R	
TOTAL	56.89	78.20	56.87	99.54	54.84	135.60	82.79

R - rain
M - mixed
S - snow

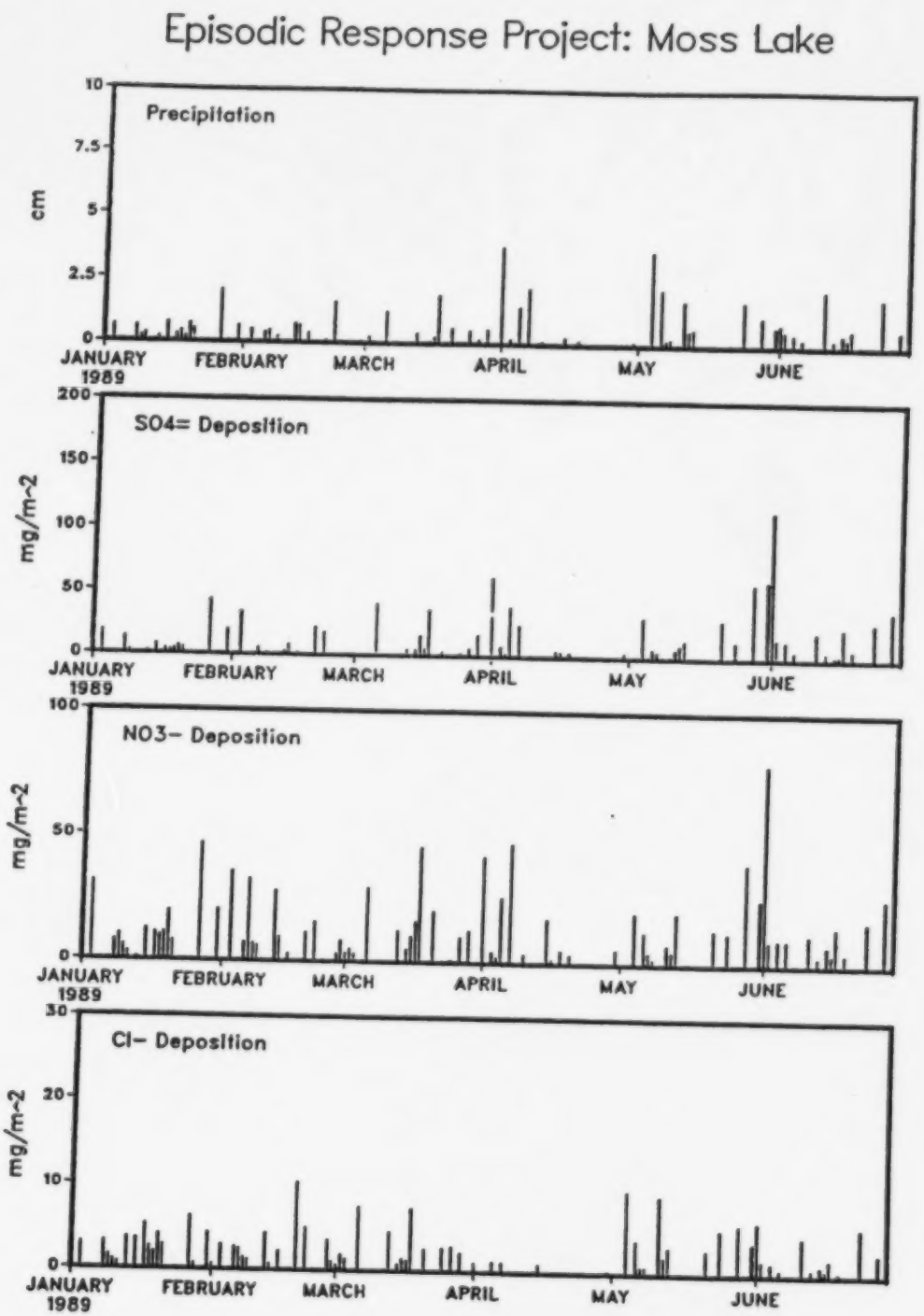


Figure 3-1. Event based precipitation amounts and calculated wet deposition measured at Moss Lake.

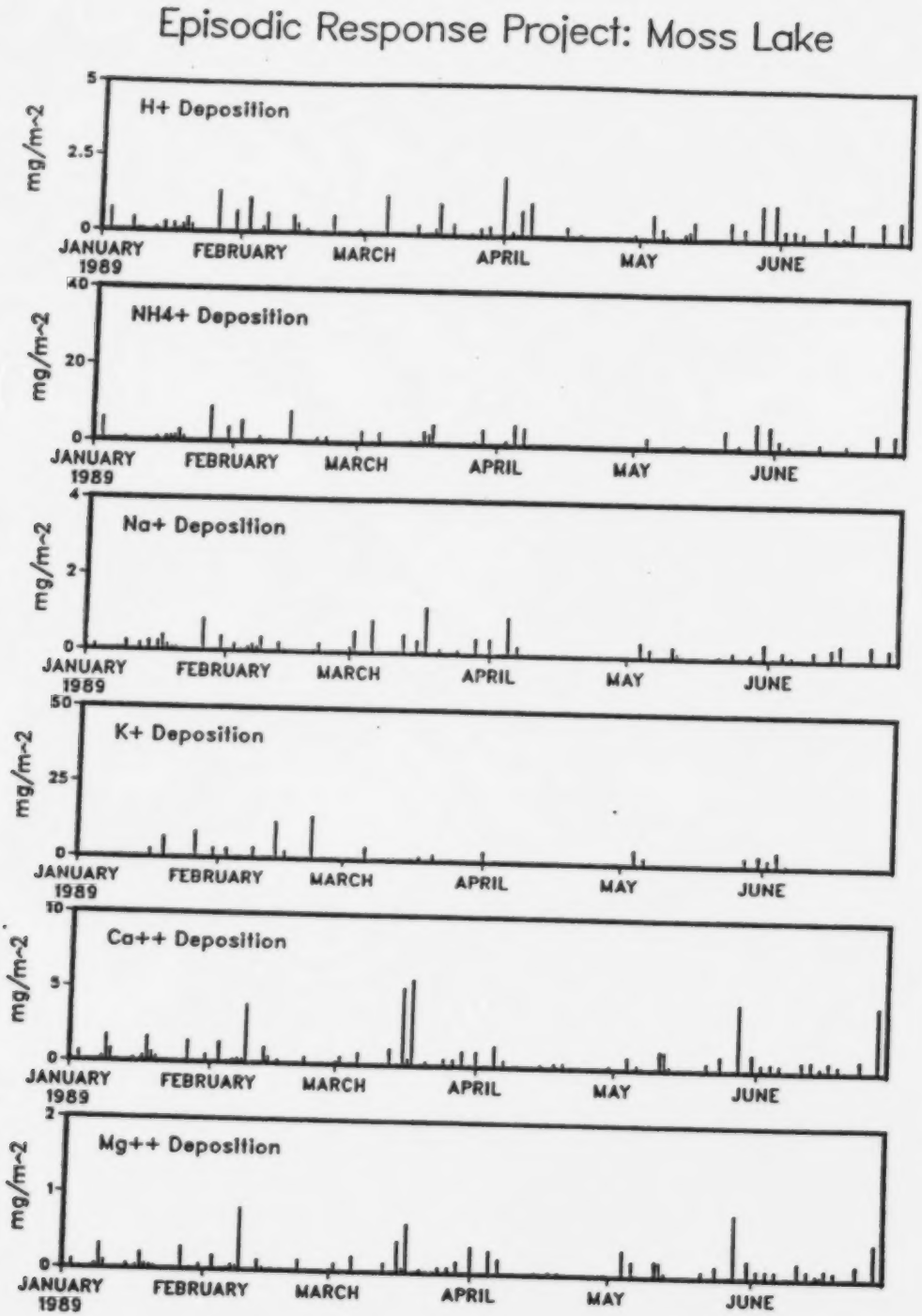


Figure 3-2. Event based wet deposition of major cations measured at Moss Lake.

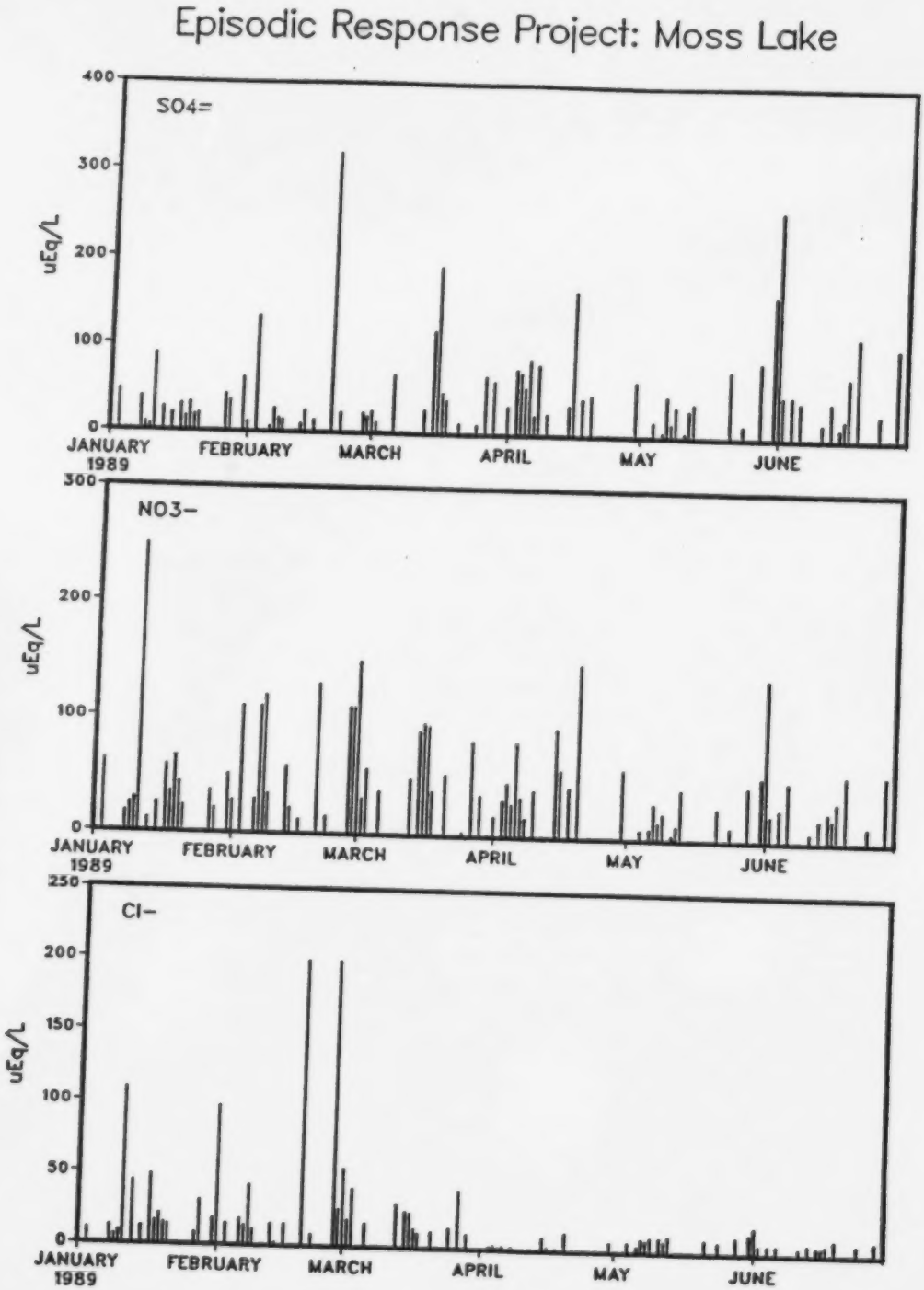


Figure 3-3. Event based concentrations of anions measured in the precipitation at Moss Lake.

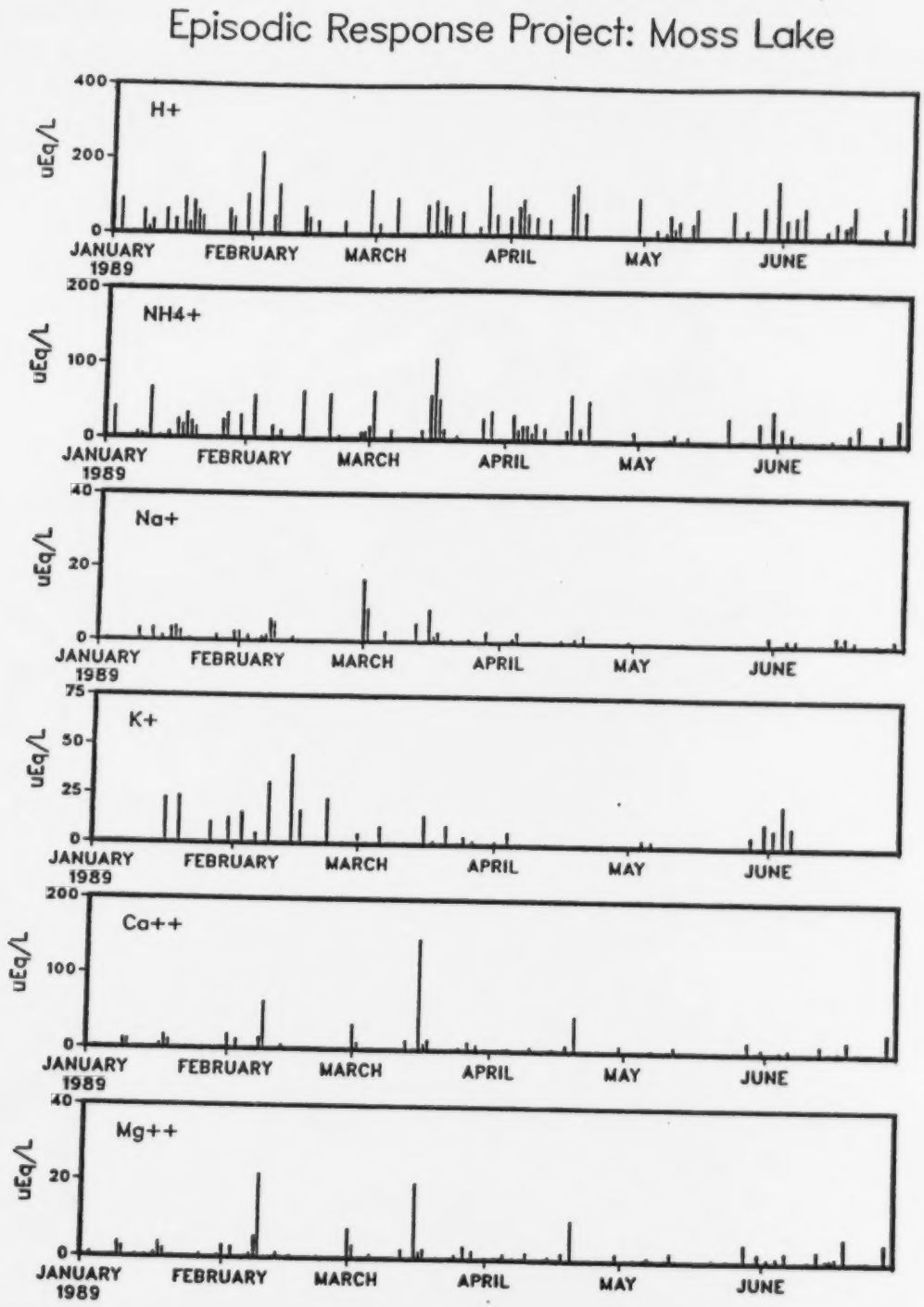


Figure 3-4. Event based concentrations of cations measured in the precipitation at Moss Lake.

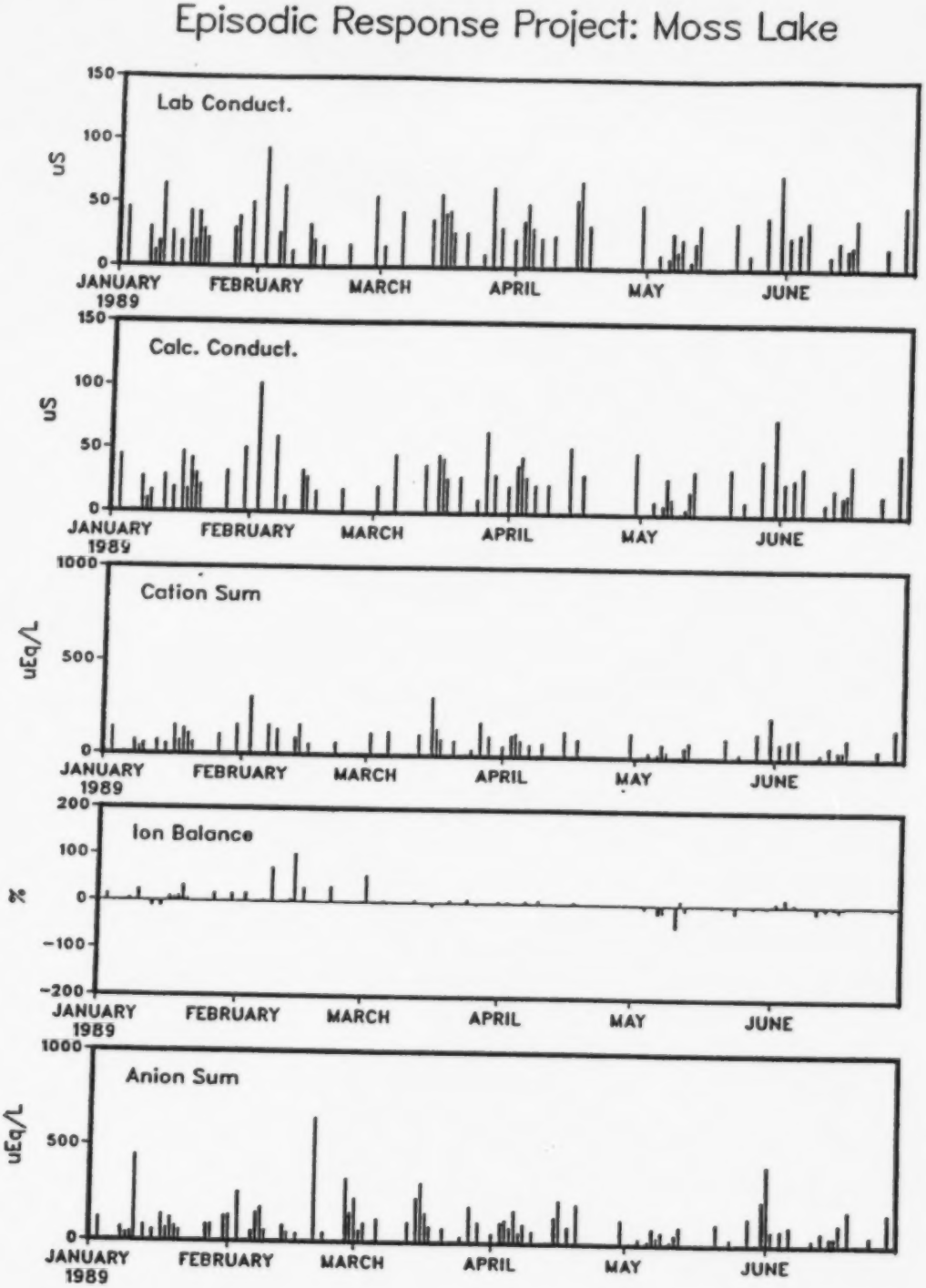


Figure 3-5. Event based concentrations for sum of the cations, anions and ion balance measured in the precipitation at Moss Lake.

5.8 ueq/l Ca; 1.6 ueq/l Mg. Figures 3-3 and 3-4 provide precipitation values for SO_4, NO_3, Cl, H^+, NH_4, Na, K, Ca, and Mg from January through June 1989. The sum of the cation, sum of the anions and ion balance during this period is provided in Figure 3-5.

3.1.2 Snow Cores

Composite snow cores were collected weekly from each quadrat from January through mid-April 1989. A total of 28 snow core samples were collected and analyzed. Results of chemical analyses for selected parameters from snow cores are provided in Tables 3-2 and 3-3 and Figure 3-6.

Snow depths ranged from 15.1 to 68.6 cm. with the maximum depth recorded at the Bald Mountain Brook site. Water equivalency of the snow core collections increased as the winter season progressed with maximum values prior to the spring melt period. The pH values of the snow pack varied throughout the season, but generally ranged between 4.45 and 5.09. Sulfate and nitrate concentrations in snow core samples for both sites were relatively constant from mid-January through early March and gradually declined into April. This decline was also observed at both sites for cations, except for ammonia. The Bald Mountain Brook site exhibited higher mean levels for all analyzed parameters as compared to Seventh Lake Inlet. Total dissolved aluminum concentrations were at or below detection limits during this period at both sites.

3.2 Hydrology

3.2.1 General

Analysis of hydrological data collected from each of the study streams indicated considerable variation among streams. Results of discharge data provided by USGS and derived from flow data collected from each stream indicated a maximum discharge of more than 0.9 $m^3/s/km^2$ at Bald Mountain Brook during the 1989 spring snow melt period that occurred in late March and early April (Figure 3-7). In contrast, during this same period a discharge of approximately 0.190 $m^3/s/km^2$ was recorded at Fly Pond Outlet. The snow melt period for each of the study streams appeared to have initiated in mid-March and lasted through mid-April. Maximum flows for most streams coincided with the major melt period that occurred during the first week in April with the exception of Fly Pond Outlet where a major fall storm occurred in early November. At least three distinct runoff episodes were associated with the overall snow melt period in all study streams.

TABLE 3-2. SNOWCORE CHEMISTRY FOR BALD MOUNTAIN BROOK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	14	4.4	4.9	4.6	0.149
Cond	uS/cm	14	7.4	22.8	16.9	4.703
ANC	ueq/l	14	-37.3	-7.6	-25.7	9.261
Ca	ueq/l	14	3.2	20.0	13.8	5.425
Mg	ueq/l	14	1.2	6.9	4.8	1.945
K	ueq/l	14	1.4	7.9	4.9	2.179
Na	ueq/l	14	-0.1	7.9	2.8	1.985
Cl	ueq/l	14	3.7	23.9	7.6	5.098
NO_3	ueq/l	14	17.5	47.0	36.8	10.038
SO_4	ueq/l	14	7.9	39.1	24.1	9.325
SiO_2	umoles/l	14	-1.6	5.4	1.7	2.536
DOC	ueq/l	13	6.0	13.2	9.4	2.100
DIC	mg/l	10	0.2	0.4	0.3	0.078
NH_4	ueq/l	14	13.2	36.9	19.6	5.876
TD Al	ug/l	14	-5.0	24.0	6.9	8.674

TABLE 3-3. SNOWCORE CHEMISTRY FOR SEVENTH LAKE INLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	14	4.4	5.0	4.6	0.190
Cond	uS/cm	14	6.5	22.2	15.2	4.664
ANC	ueq/l	14	-38.8	-3.7	-23.0	9.912
Ca	ueq/l	14	3.1	14.6	10.5	3.577
Mg	ueq/l	14	1.1	5.6	3.6	1.340
K	ueq/l	14	1.6	5.2	3.4	1.187
Na	ueq/l	14	0.0	6.4	2.6	1.596
Cl	ueq/l	14	3.2	16.0	6.2	3.106
NO_3	ueq/l	14	16.4	42.2	32.4	9.153
SO_4	ueq/l	14	5.9	25.6	18.8	6.722
SiO_2	umoles/l	14	-1.6	5.4	1.7	2.507
DOC	ueq/l	14	5.7	16.2	8.8	2.661
DIC	mg/l	10	0.1	0.5	0.3	0.137
NH_4	ueq/l	14	11.2	18.6	16.0	2.238
TD Al	ug/l	14	-2.6	35.8	9.1	9.141
O18		1	-14.8	-14.8	-14.8	

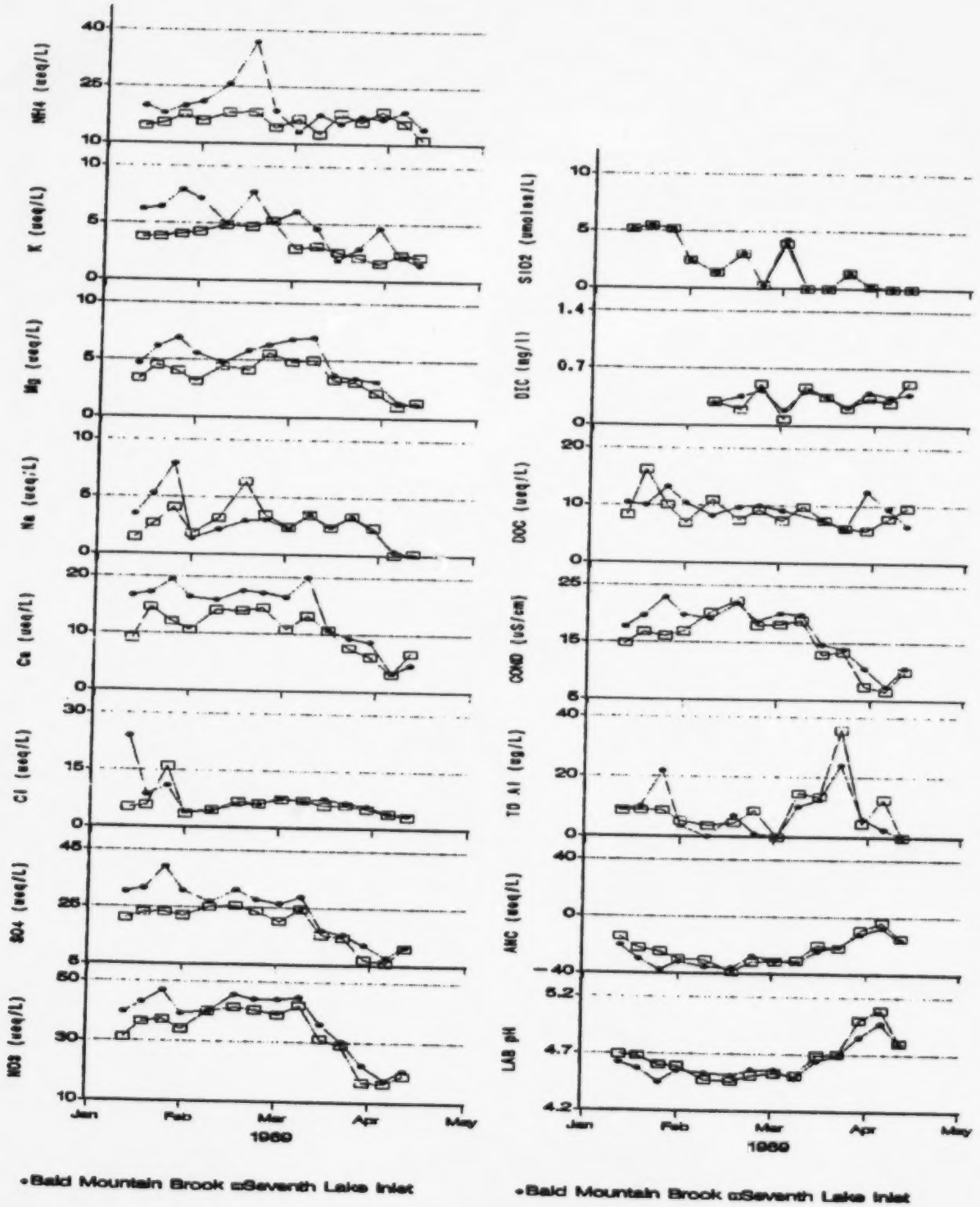


Figure 3-6. Analytical results for snow core samples taken from Bald Mountain Brook and Seventh Lake Inlet (January to April 1989).

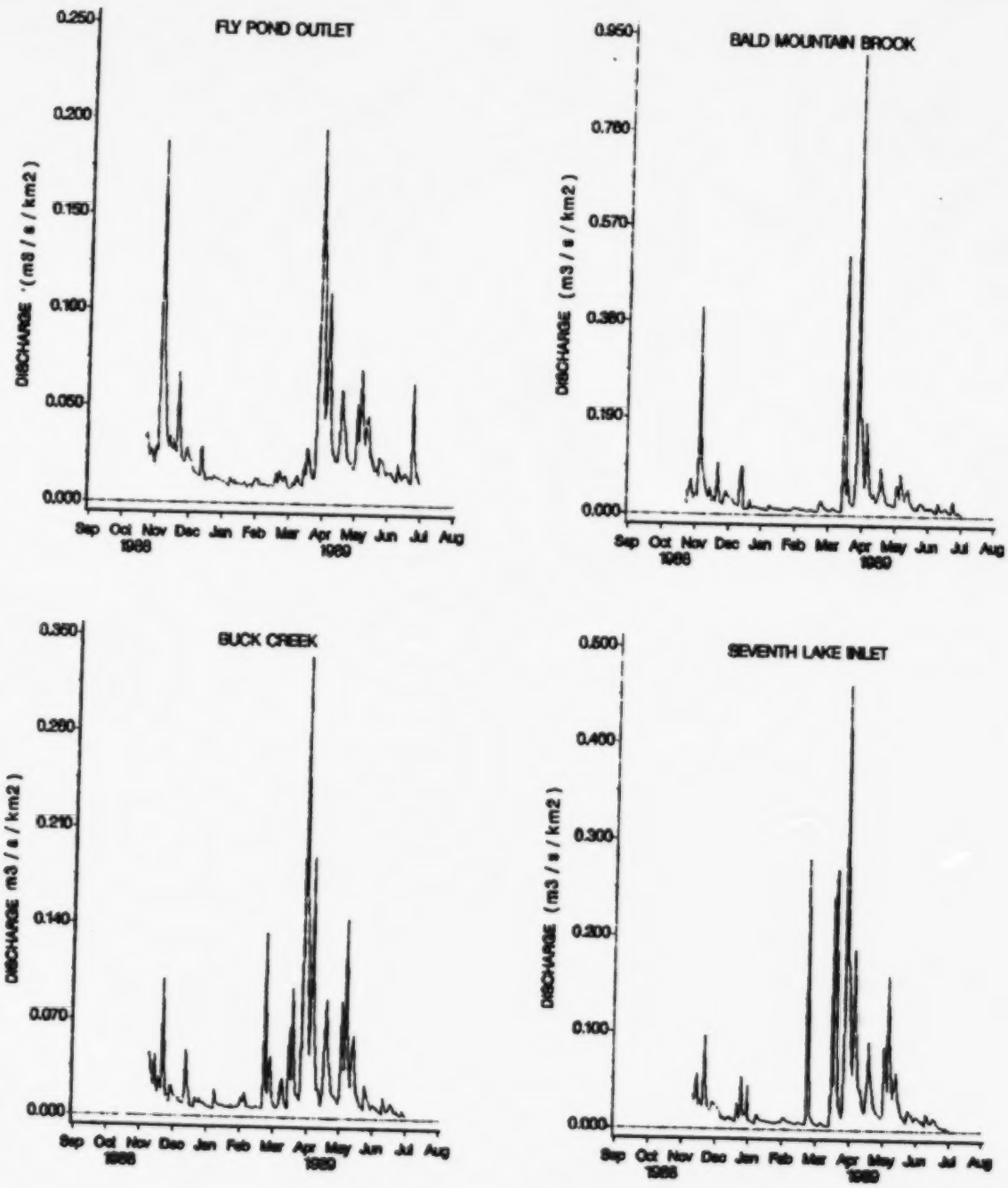


Figure 3-7. Stream discharge data for individual study streams from October 1988 through June 1989. ($m^3/s/km^2$)

When discharge is expressed as m^3/s (disregarding watershed size), the greatest flow was recorded at Seventh Lake Inlet at nearly 3.00 m^3/s (Figure 3-8).

Flow duration curves for comparing study streams indicated that Bald Mountain Brook had the highest discharge (1.7 $m^3/s/km^2$) and Fly Pond Outlet the lowest (0.22 $m^3/s/km^2$) (Figure 3-9). Seventh Lake Inlet and Buck Creek were similar in discharge; however, Seventh Lake Inlet appeared to maintain a higher discharge for a longer period. Flow responses were of greater magnitude in Bald Mountain Brook than were observed in the other streams.

3.2.2 Episodes

From December 1988 through June 1989, a total of six major rain events with at least 2.0 cm of precipitation were identified (Figure 3-1). Based on the stream discharge data, four to six events were observed, based on the minimum flow level selected and the specific stream examined. As noted, the magnitude and duration varied greatly among events from less than 24 hours duration to the intense spring snow melt episode that lasted approximately one week. Two major events were identified for discussion in this report. The largest and most severe episode that occurred was the spring snow melt beginning approximately 27 March and lasting about seven days. A smaller but also significant event was a spring storm in early May lasting several days. Selected water chemistry and flow data for each study stream are provided for each of these hydrologic events in Figures 3-10 through 3-17. During the spring snow melt episode, water chemistry varied dramatically by stream. In general, Fly Pond Outlet data exhibited the least amount of chemical change while the most severe changes in water chemistry were observed in Buck Creek. The lowest pH (4.5) observed among the study streams was found in Buck Creek during the spring snow melt period. Less dramatic changes were observed in the other three streams.

The duration of the snowmelt period also varied by stream. The snowmelt period with the longest duration occurred at Seventh Lake Inlet, the stream with the largest watershed. The shortest snowmelt period occurred in Bald Mountain Brook.

Stream chemistry changed rapidly in response to increases in flow. Increased flow was associated with depressions in pH, ANC, DOC and elevated dissolved aluminum values. The highest total dissolved aluminum values were observed during events in Buck Creek and Seventh Lake Inlet during November of 1988.

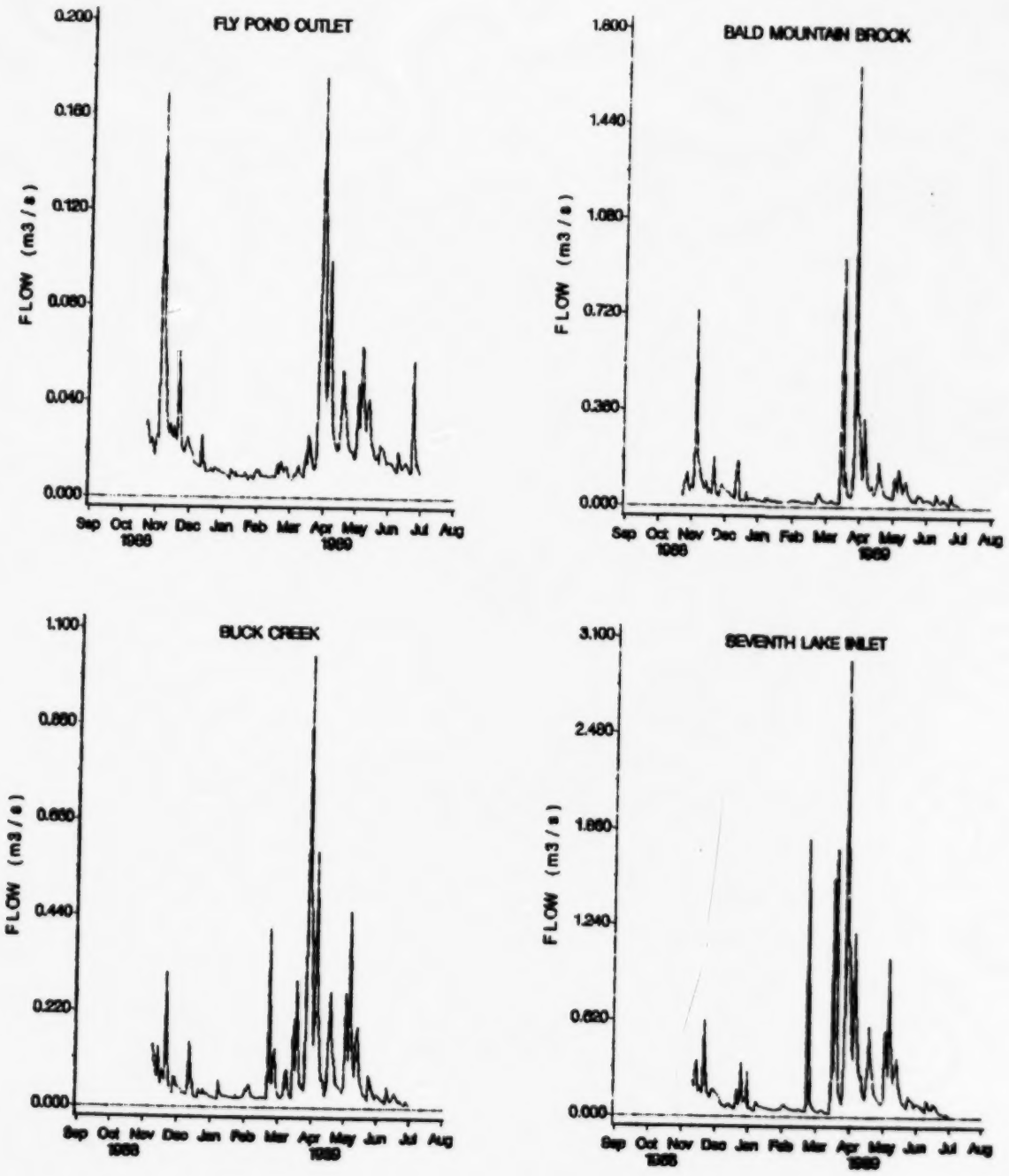


Figure 3-8. Stream flow data for individual study streams from October 1988 through June 1989. (m^3/s)

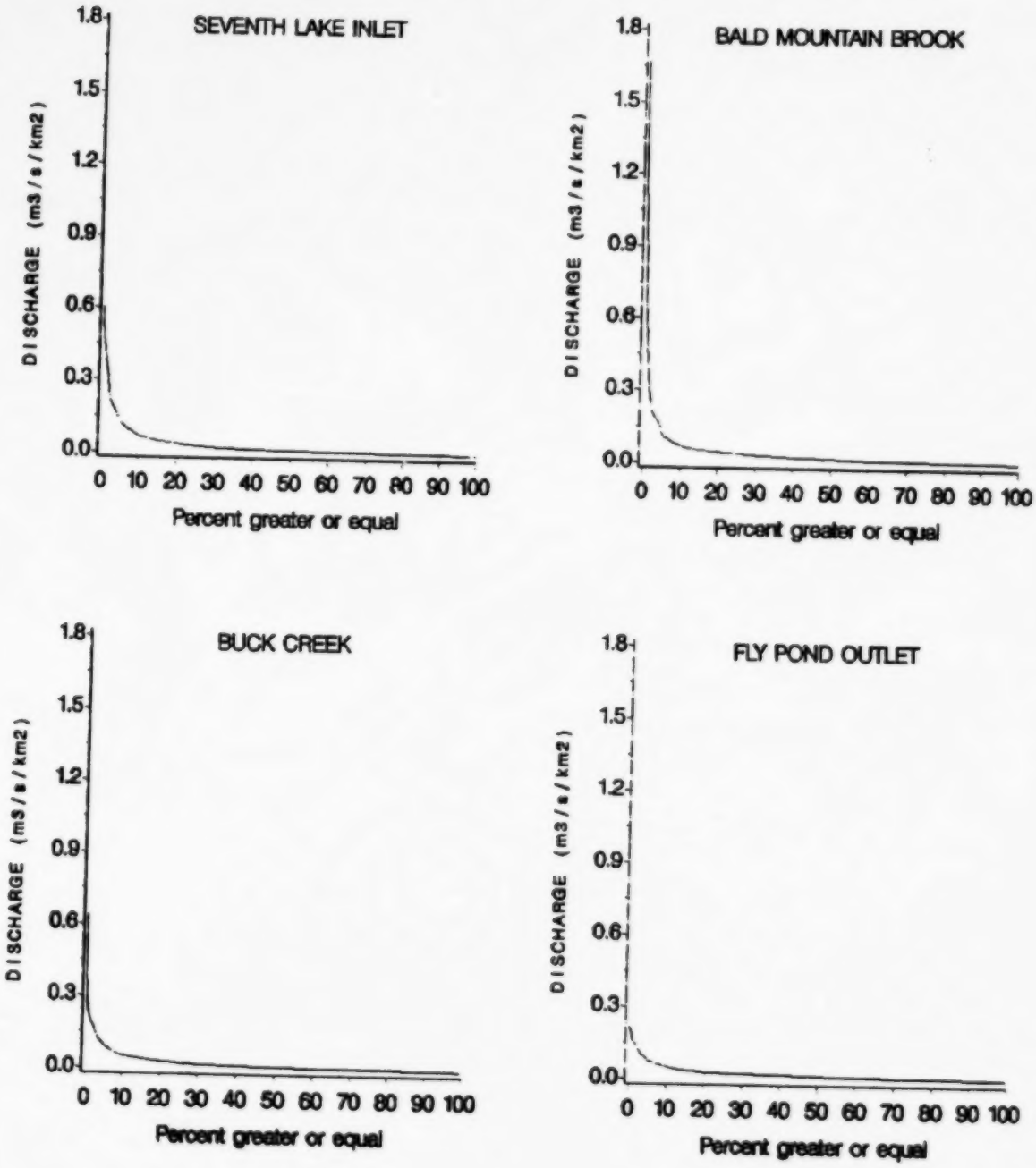


Figure 3-9. Flow duration curves for Adirondack study streams 1 November 1988 to 30 June 1989.

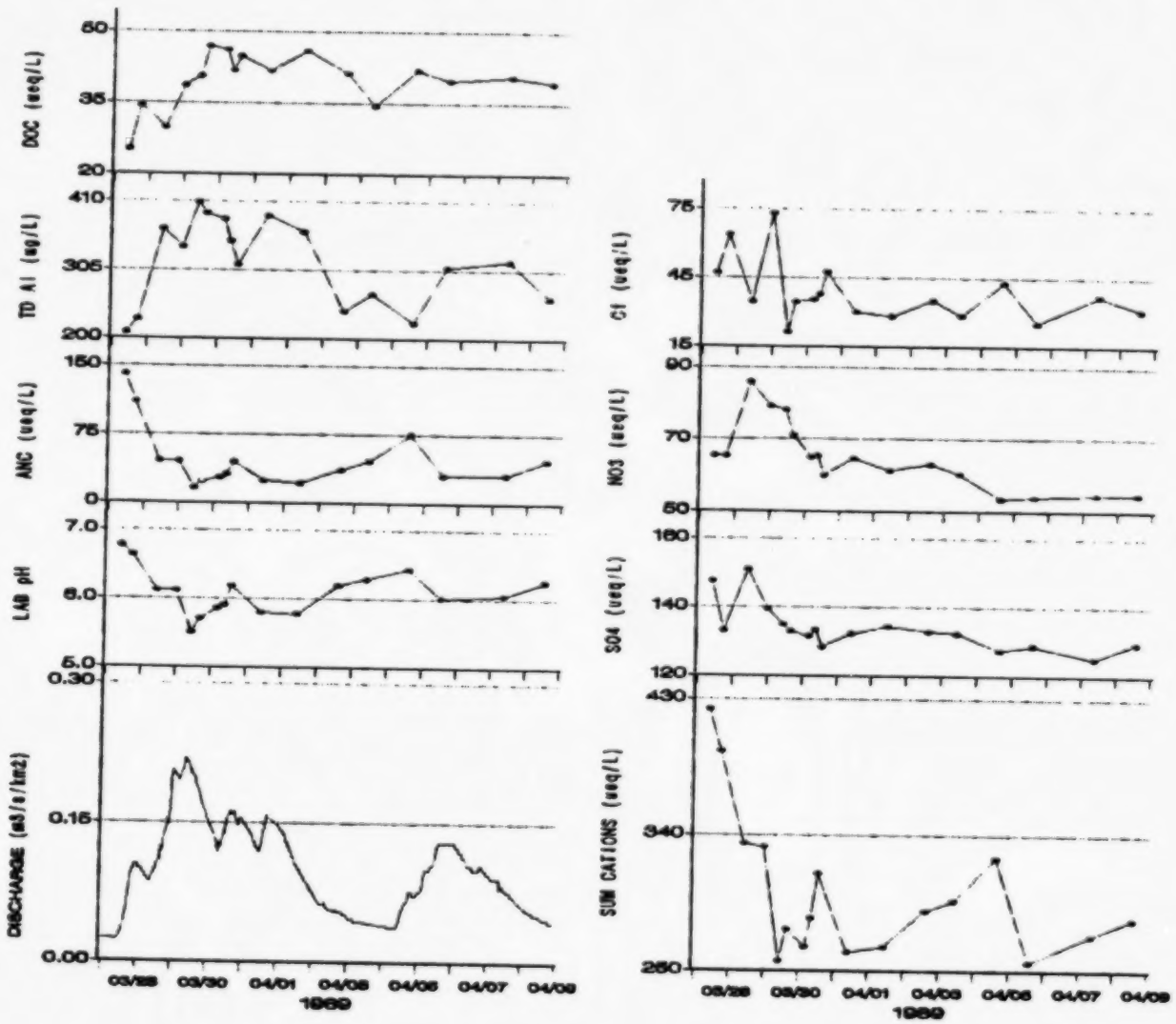


Figure 3-10. Selected chemistry and discharge for the spring snowmelt for Fly Pond Outlet (25 March - 4 April 1989).

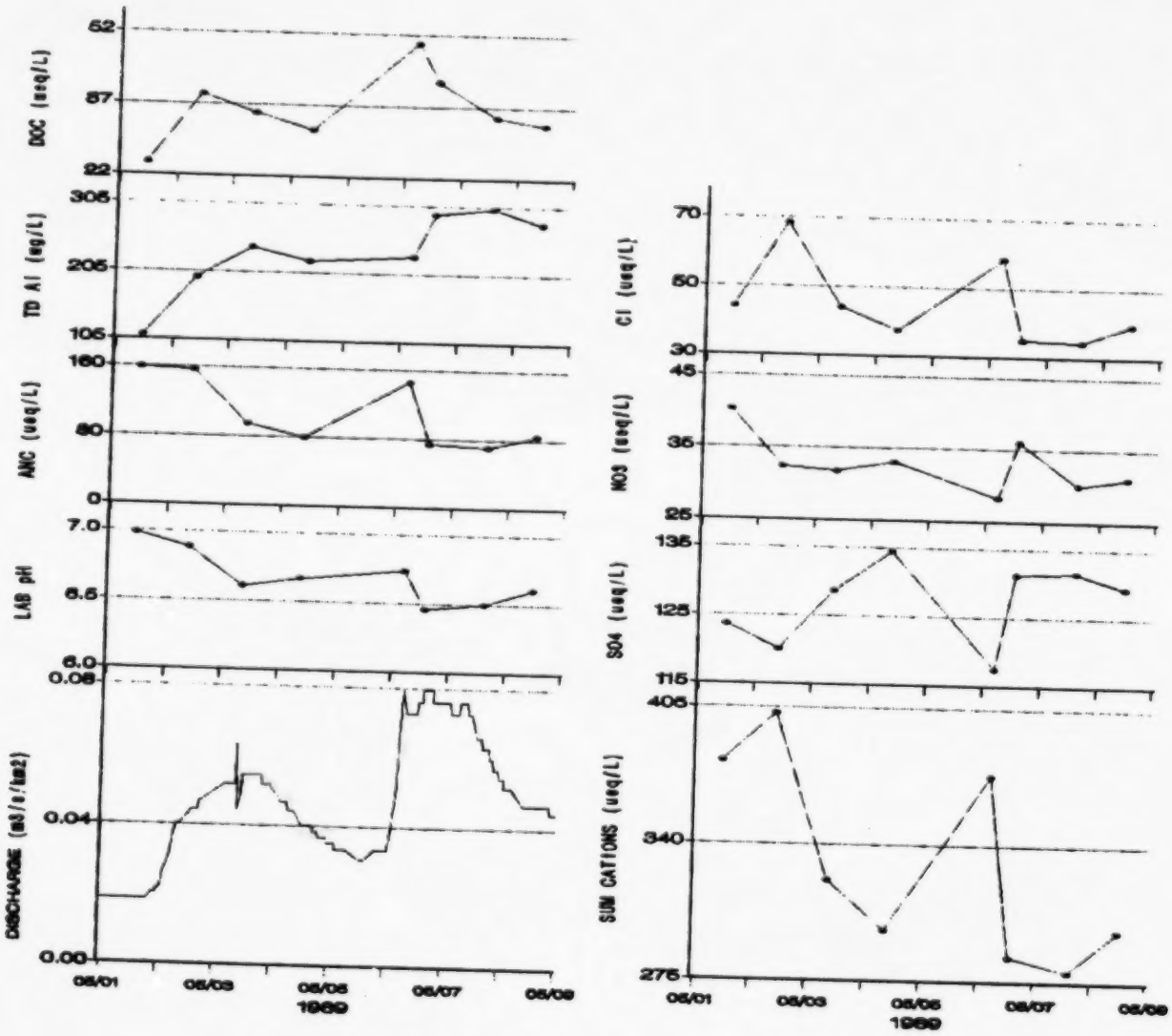


Figure 3-11. Selected chemistry and discharge for a spring storm on Fly Pond Outlet (1 May - 9 May 1989).

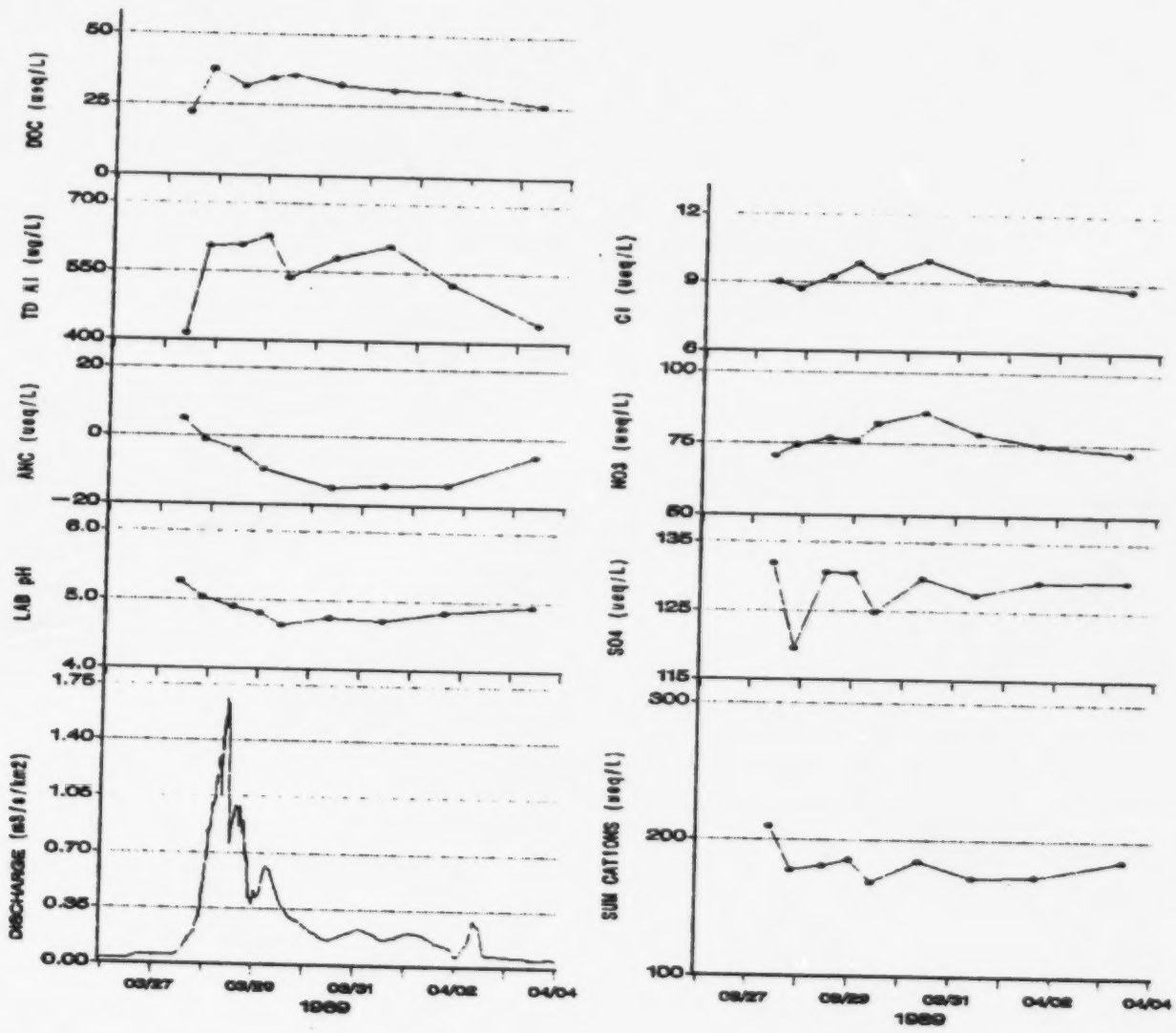


Figure 3-12. Selected chemistry and discharge for the spring snowmelt for Bald Mountain Brook (25 March - 4 April 1989).

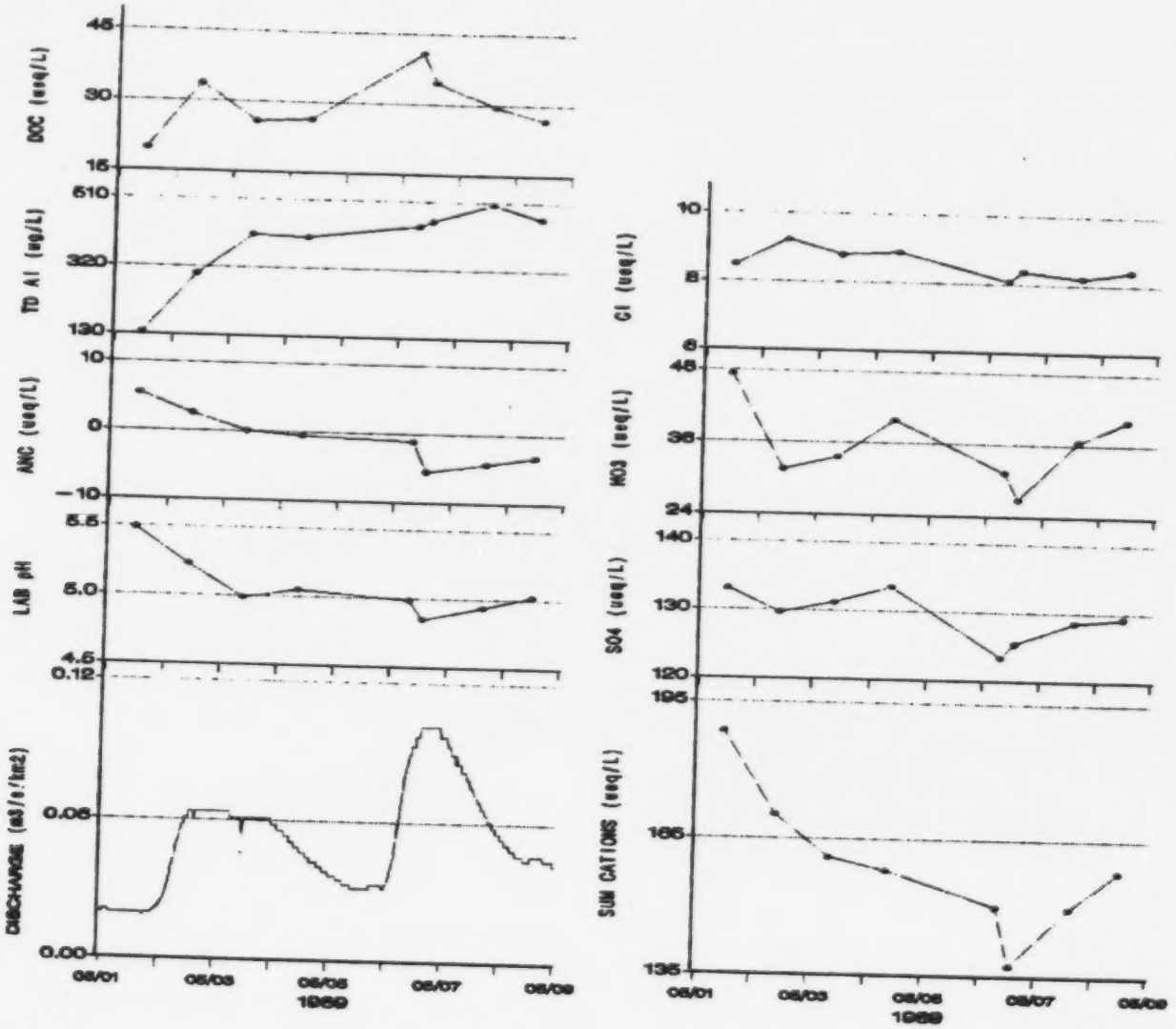


Figure 3-13. Selected chemistry and discharge for a spring storm on Bald Mountain Brook (1 May - 9 May 1989).

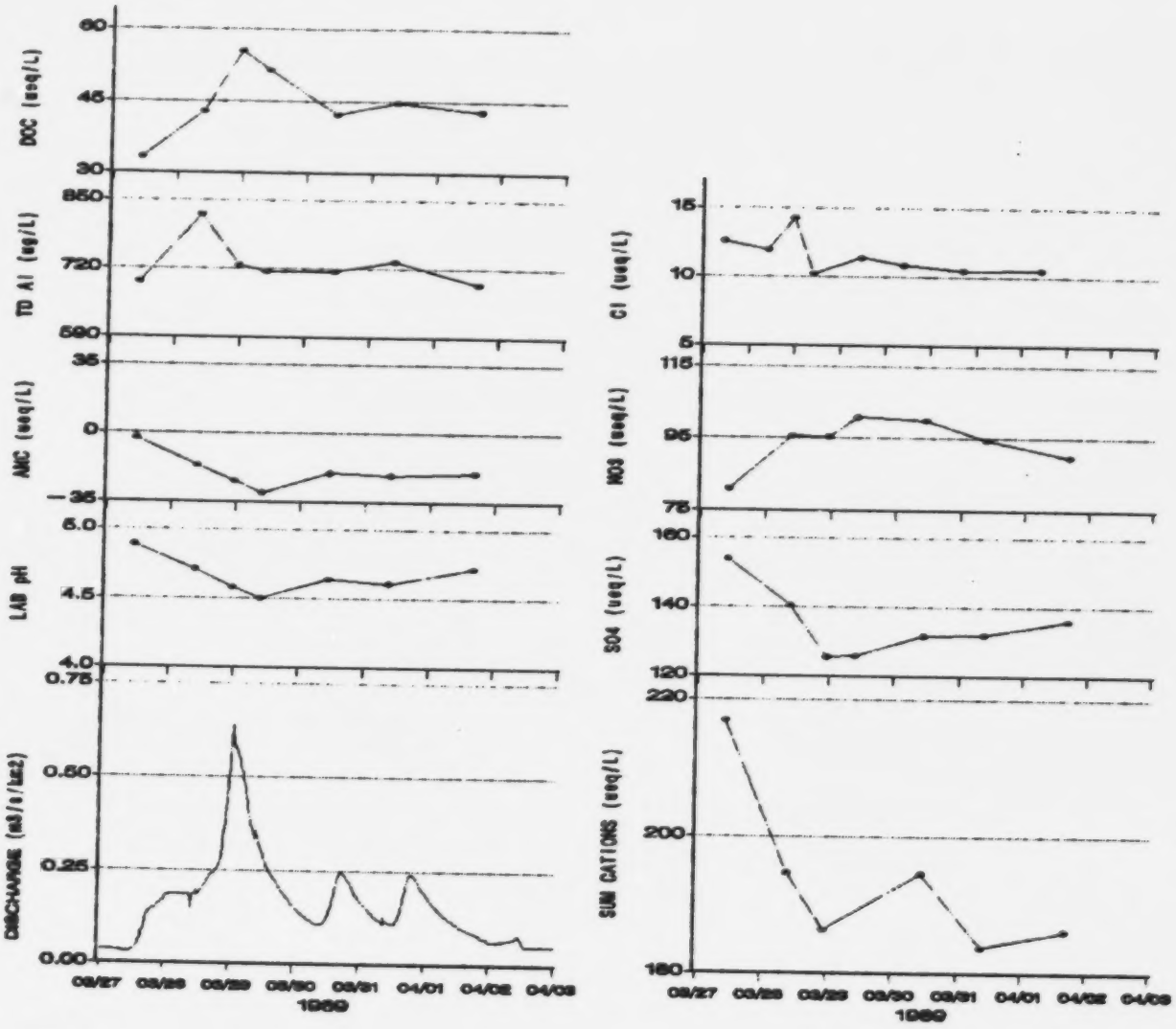


Figure 3-14. Selected chemistry and discharge for the spring snowmelt for Buck Creek (25 March - 4 April 1989).

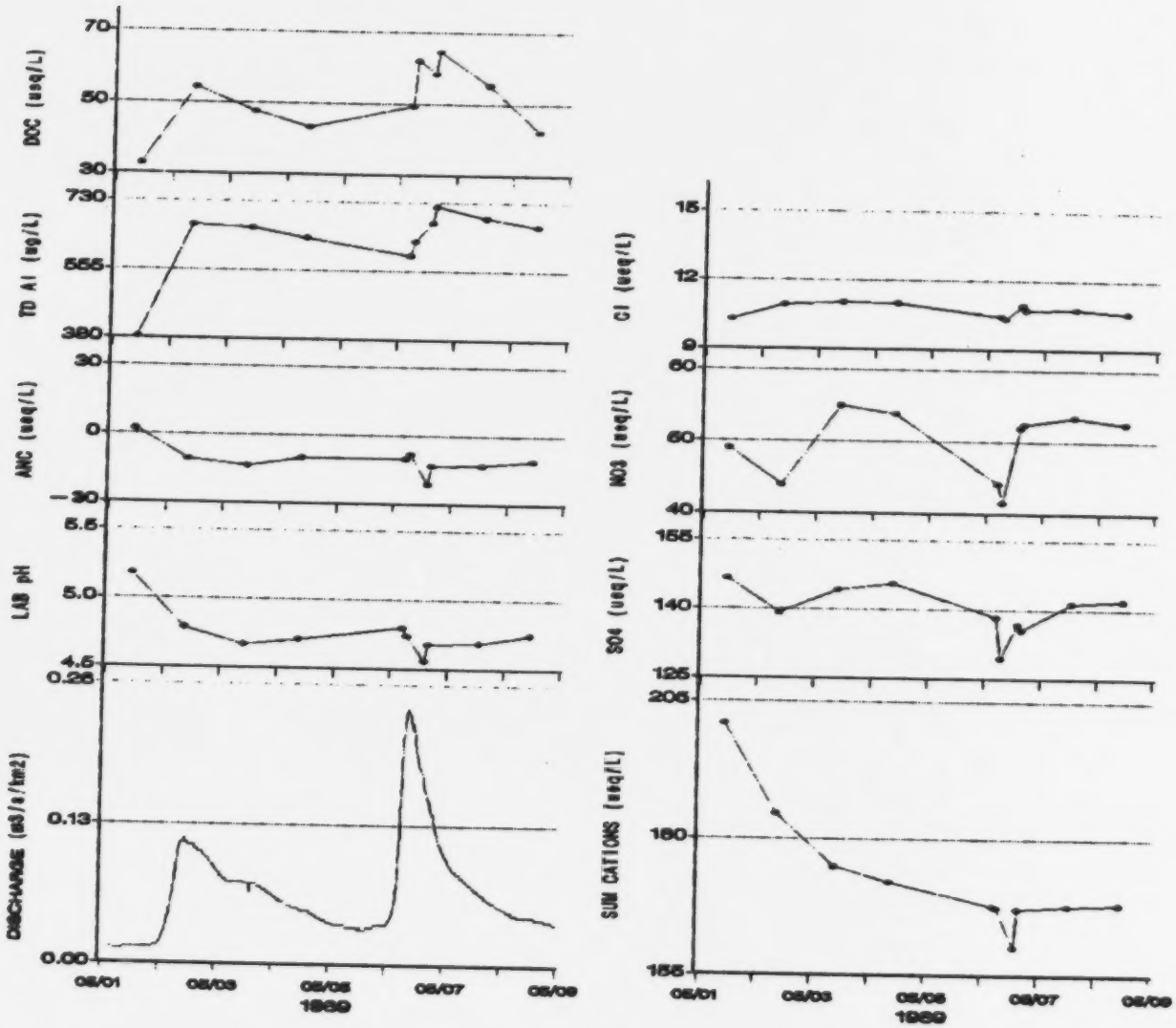


Figure 3-15. Selected chemistry and discharge for a spring storm on Buck Creek (1 May - 9 May 1989).

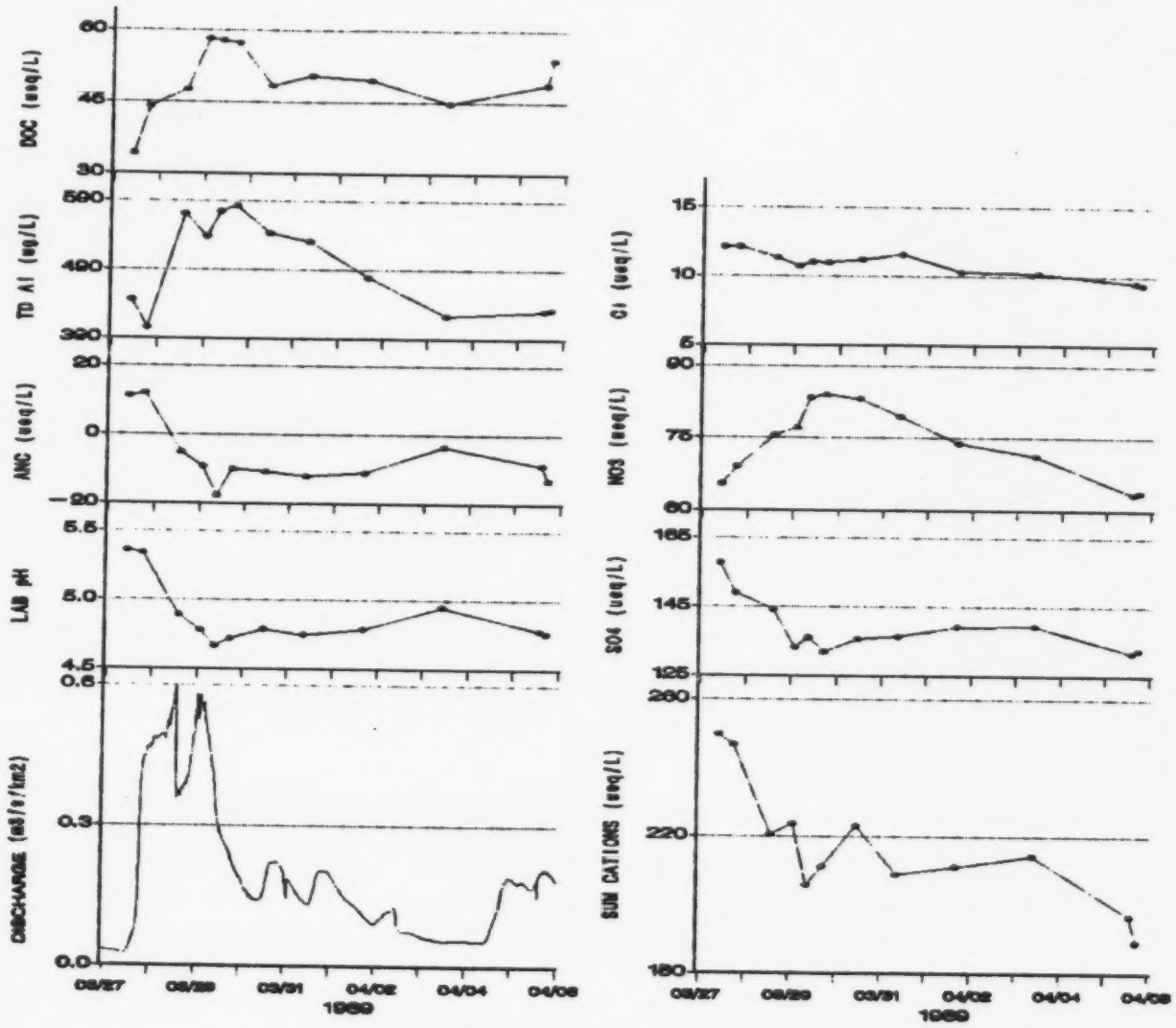


Figure 3-16. Selected chemistry and discharge for the spring snowmelt for Seventh Lake Inlet (25 March - 4 April 1989).

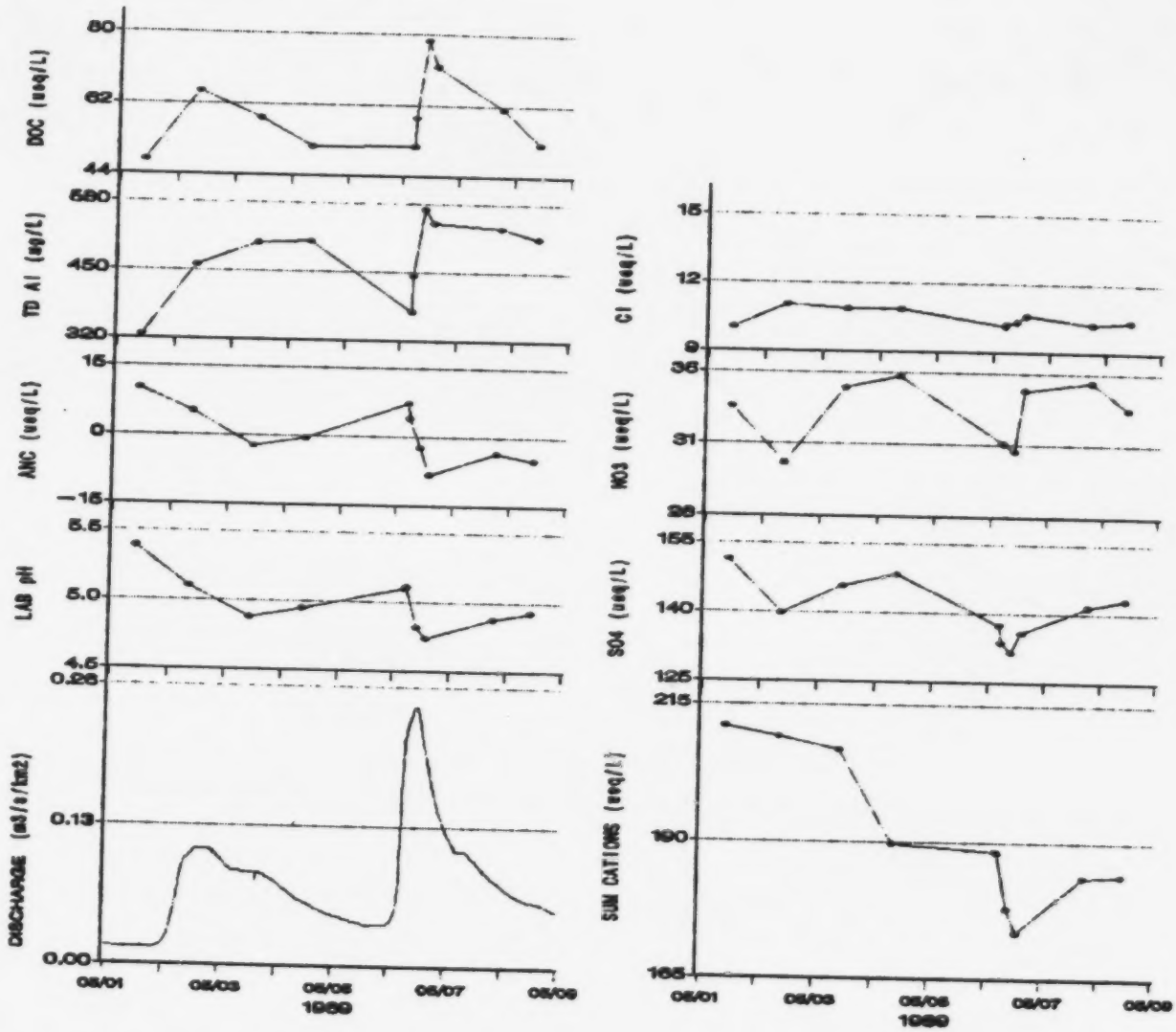


Figure 3-17. Selected chemistry and discharge for a spring storm on Seventh Lake Inlet (1 May - 9 May 1989).

3.3 Water Chemistry

3.3.1 Chemical Parameters

Water chemistry analyses were conducted for 725 samples from July 1988 through June 1989. A total of 7707 analyses were performed in the ALSC laboratory during this period, not including analyses related to the QA/QC program. A summary of sample analyses performed in the laboratory including holding time requirements is provided in Table 3-4. Temporal variation in chemistry was observed in all streams during the investigation period (Figures 3-18 through 3-21). Buck Creek exhibited greatest changes in chemistry and appeared to be the most responsive to hydrologic events. The most severe chemical changes occurred during the spring snowmelt period for all streams, while little variation occurred under low flow conditions from January through late February and again during June. Summary base flow and event water chemistry are provided for all parameters collected during this study period (Tables 3-5 through 3-16). Water quality during low flow periods was greatly improved as compared to event chemistry. Mean values presented in these tables are not weighted to stream flow. The conversion of DOC from mg/l to ueq/l was derived from Eshelman and Hemond (1985).

Under baseflow conditions, water chemistry varied considerably among streams. The highest baseflow pH and ANC were found in Fly Pond Outlet and the lowest pH and ANC observed in Buck Creek. The highest baseflow total dissolved aluminum was in Buck Creek with the lowest in Fly Pond Outlet. The highest baseflow DOC and sulfate values, and the lowest baseflow nitrate values were observed in Seventh Lake Inlet.

3.3.2 Quality Assurance/Quality Control

Results of synthetic and natural audit data are summarized in Tables 3-17 through 3-21. The Data Quality Objectives (DQO) for bias, relative bias, precision and relative precision are included. The results of field blank data are provided in Table 3-22.

Results of the LRTAP round robin sample analysis including date received, number of parameters analyzed, number of parameters biased, percent of parameters biased, number of results ranked, number of flags assigned, percent of results flagged and the sum of percent biased and percent flagged (score) are provided in Table 3-23. The number of parameters analyzed has increased and the results have shown continued improvement through the first four LRTAP studies.

TABLE 3-4. SUMMARY OF SAMPLE ANALYSES AND ASSOCIATED HOLDING TIME REQUIREMENTS

Parameter	Number of Analyses	ERP Recommended Holding Time	Percentage of Samples Meeting Holding Times	
			EPA	ERP
Lab pH	725	7 days	>99	>99
ANC	724	14 days	100	100
S. Cond	673	14 days	100	100
Cl	387	14 days	91	91
SO_4	388	14 days	91	91
NO_3	387	14 days	91	91
DIC	307	14 days	>99	>99
DOC	627	14 days	>99	>99
SO_2	421	14 days	100	>99
NH_4	422	14 days	100	>99
Ca	504	28 days *	100	80
Mg	499	28 days *	100	80
Na	498	28 days *	100	80
K	503	28 days *	100	80
TD Al	584	14 days *	100	38
TM Al	29	14 days	---	100
OM Al	29	14 days	---	90

* EPA holding requirements for these parameters is six months.

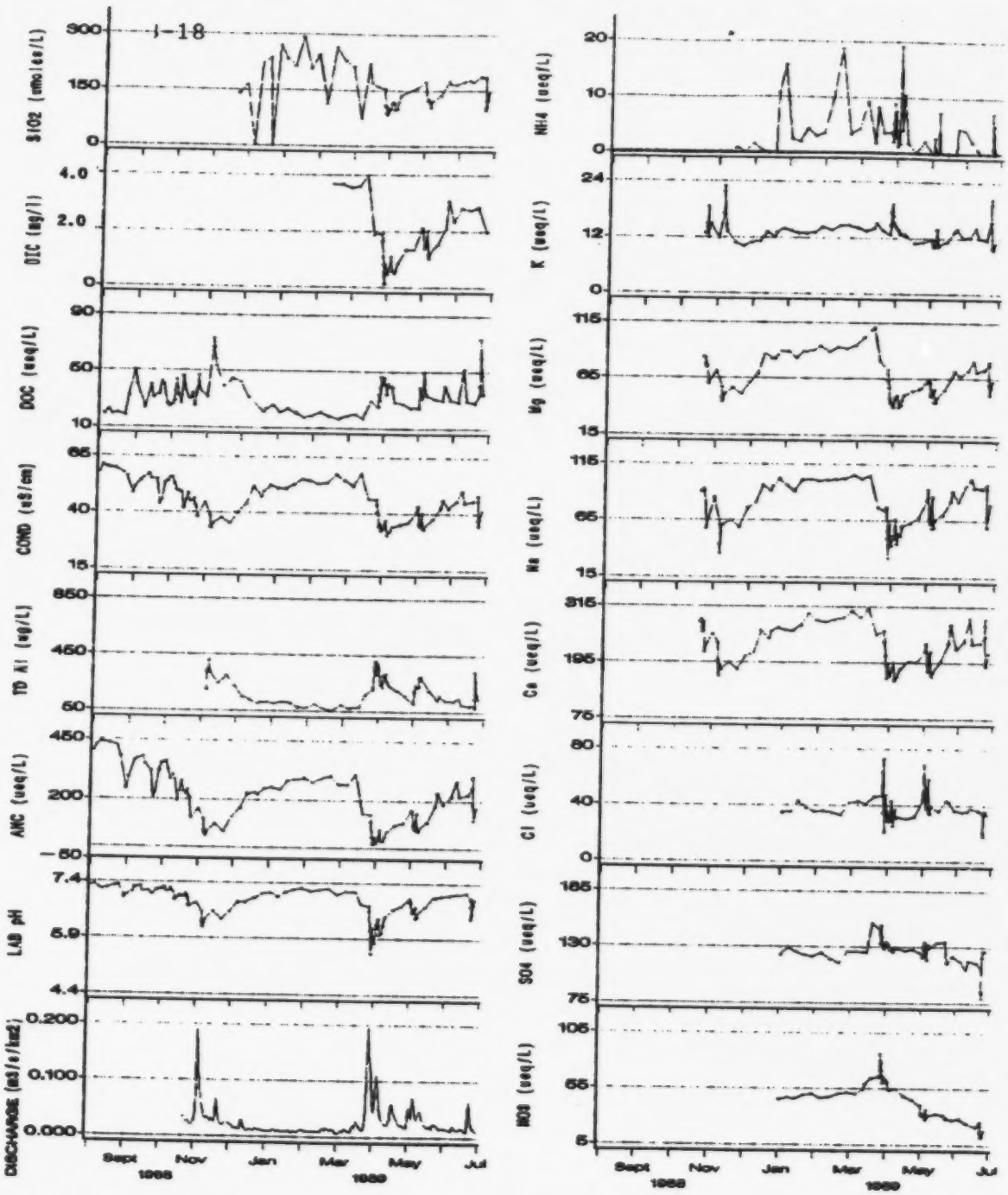


Figure 3-18. Temporal variations in stream chemistry for Fly Pond Outlet September 1988 through June 1989.

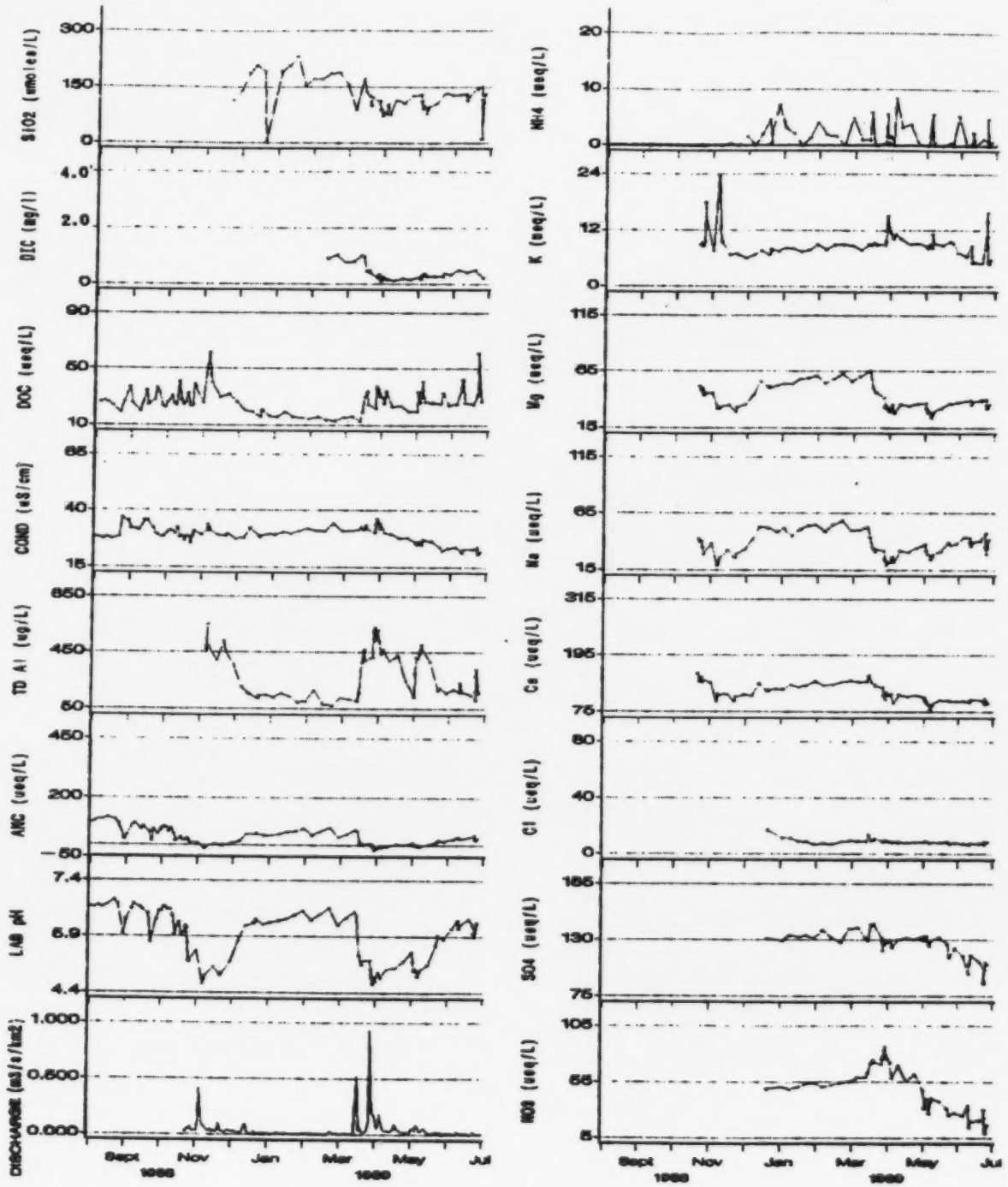


Figure 3-19. Temporal variations in stream chemistry for Bald Mountain Brook September 1988 through June 1989.

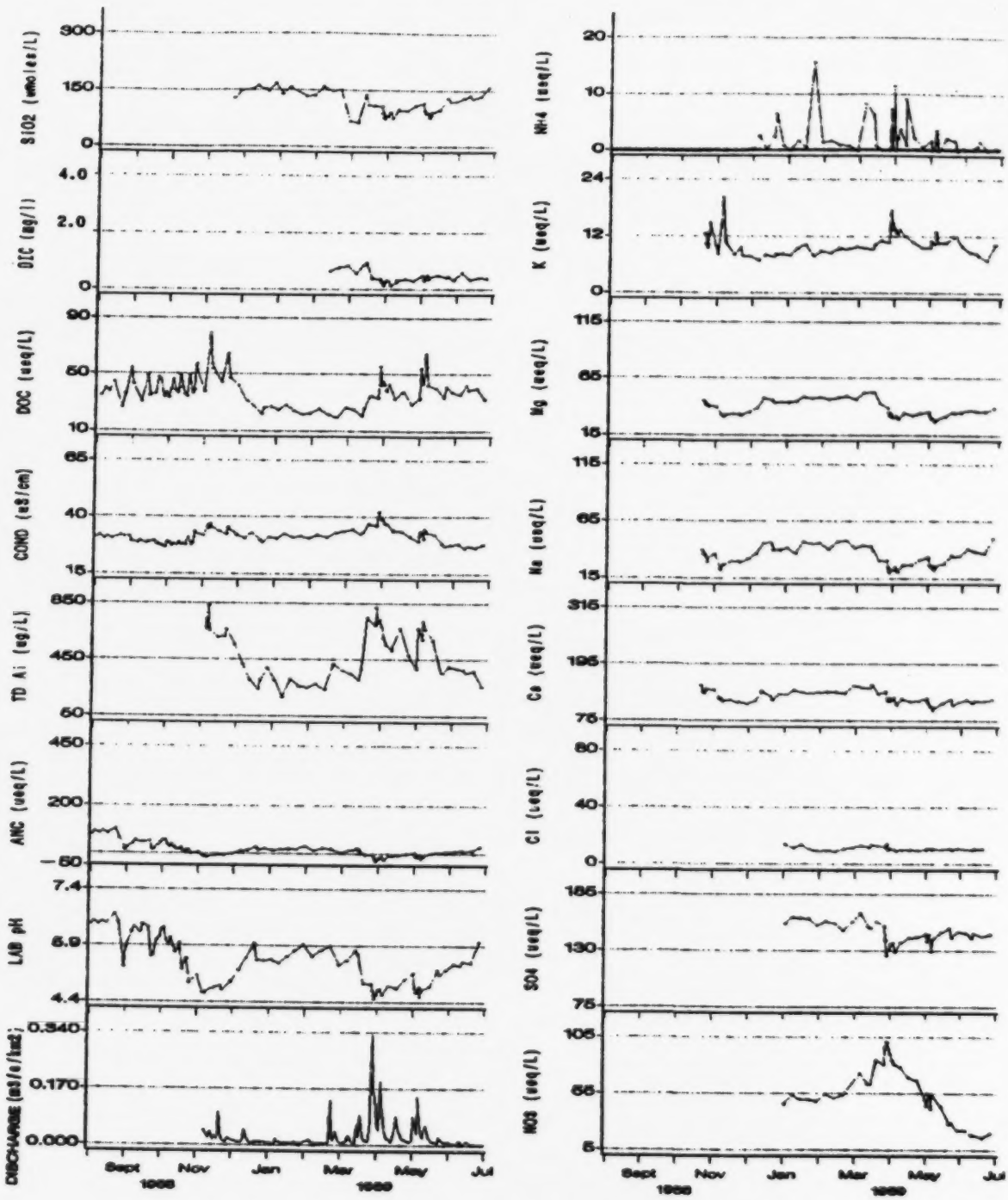


Figure 3-20. Temporal variations in stream chemistry for Buck Creek September 1988 through June 1989.

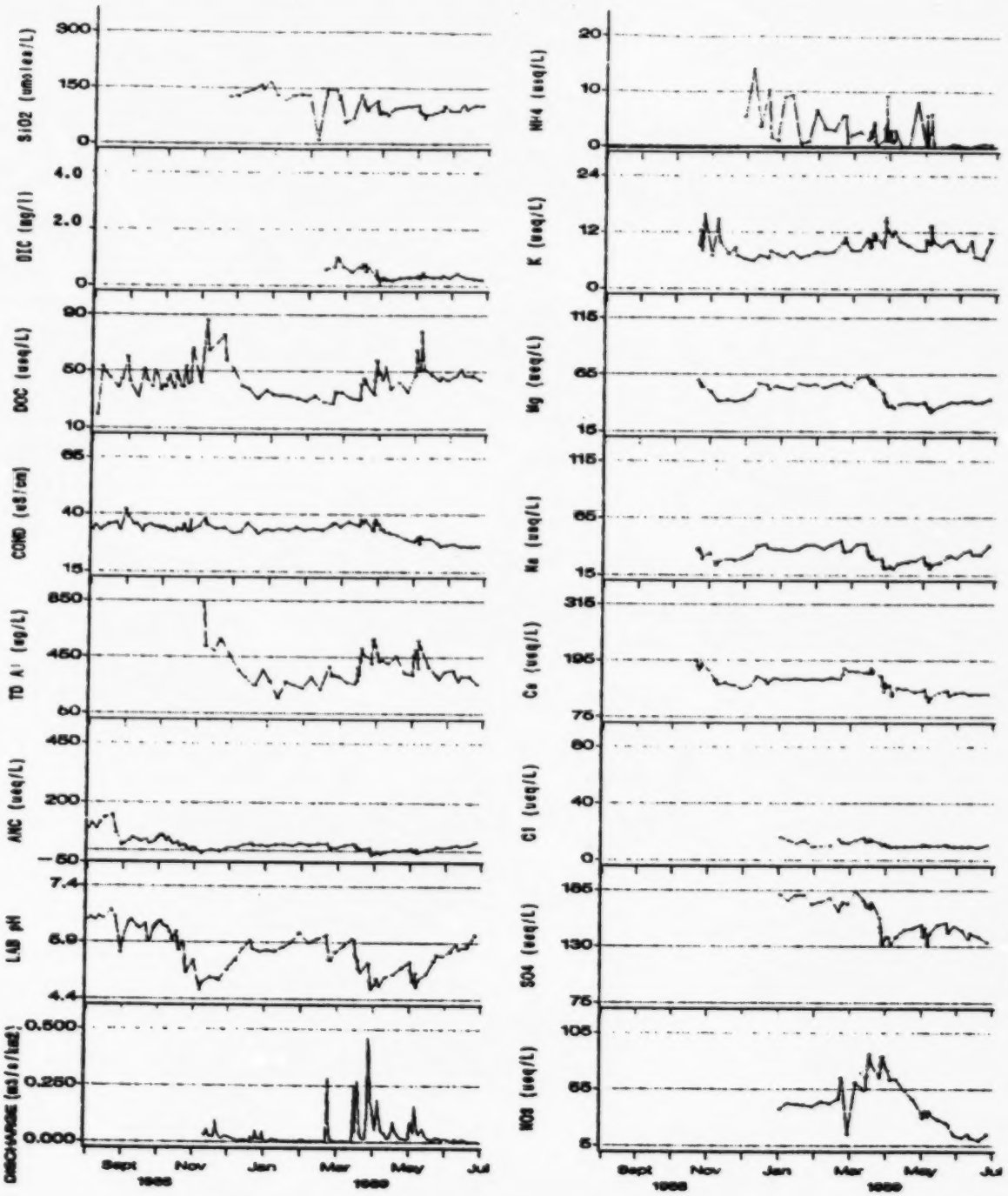


Figure 3-21. Temporal variations in stream chemistry for Seventh Lake Inlet September 1988 through June 1989.

TABLE 3-5. TOTAL STREAM WATER CHEMISTRY FOR FLY POND OUTLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	107	5.5	7.3	6.8	0.428
Cond	uS/cm	106	30.6	60.8	44.8	8.511
ANC	ueq/l	107	17.0	442.2	202.2	119.072
Ca	ueq/l	78	158.6	310.6	226.5	44.299
Mg	ueq/l	79	40.0	110.9	65.4	18.267
K	ueq/l	79	9.5	22.9	13.8	2.731
Na	ueq/l	78	31.6	105.4	74.4	20.318
Cl	ueq/l	55	18.3	73.2	37.9	10.152
NO_3	ueq/l	56	12.4	86.0	45.0	18.096
SO_4	ueq/l	56	80.3	153.4	124.9	13.181
SiO_2	umoles/l	63	2.5	293.9	145.9	58.009
DOC	ueq/l	101	16.4	73.7	35.2	12.696
DIC	mg/l	43	0.1	4.2	1.8	1.173
NH_4	ueq/l	62	-1.0	19.2	3.8	4.434
TD Al	ug/l	70	59.9	409.2	210.5	102.463
OM Al	ug/l	4	60.8	83.0	71.2	9.741
TM Al	ug/l	4	55.9	181.7	108.2	53.940

TABLE 3-6. TOTAL STREAM WATER CHEMISTRY FOR BALD MOUNTAIN BROOK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	105	4.6	6.8	5.8	0.697
Cond	uS/cm	105	20.6	36.6	28.9	3.695
ANC	ueq/l	105	-20.4	116.6	31.8	34.231
Ca	ueq/l	77	77.8	156.8	114.9	18.731
Mg	ueq/l	77	23.8	65.2	41.2	10.630
K	ueq/l	77	4.7	23.8	9.4	3.623
Na	ueq/l	77	18.6	58.2	35.8	10.643
Cl	ueq/l	53	6.7	17.0	8.8	1.706
NO_3	ueq/l	53	9.4	85.8	47.4	21.103
SO_4	ueq/l	53	87.6	145.4	124.5	13.808
SiO_2	umoles/l	59	2.1	231.6	120.7	46.380
DOC	ueq/l	100	12.9	61.6	29.1	10.419
DIC	mg/l	38	0.1	1.1	0.4	0.278
NH_4	ueq/l	60	-0.8	8.4	1.5	2.128
TD Al	ug/l	68	73.2	650.6	314.0	171.228
OM Al	ug/l	4	54.7	168.0	107.1	52.233
TM Al	ug/l	4	125.5	294.6	182.5	76.419
O18		11	-13.4	-12.0	-12.8	0.452

TABLE 3-7. TOTAL STREAM WATER CHEMISTRY FOR BUCK CREEK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	97	4.5	6.7	5.4	0.636
Cond	uS/cm	97	26.2	42.3	31.6	3.483
ANC	ueq/l	96	-30.1	100.7	15.2	28.707
Ca	ueq/l	68	98.0	150.8	123.9	12.807
Mg	ueq/l	69	26.8	52.6	37.5	6.942
K	ueq/l	69	6.8	20.2	11.0	2.996
Na	ueq/l	69	19.8	50.0	32.5	8.305
Cl	ueq/l	44	8.9	14.3	11.1	1.222
NO_3	ueq/l	44	16.2	100.8	57.2	23.930
SO_4	ueq/l	45	125.5	166.5	145.4	10.225
SiO_2	umoles/l	51	64.8	166.7	112.8	29.431
DOC	ueq/l	93	19.6	79.1	40.8	12.891
DIC	mg/l	38	0.1	1.0	0.4	0.193
NH_4	ueq/l	52	-0.8	15.6	2.0	3.242
TD Al	ug/l	60	185.5	834.5	517.9	180.459
OM Al	ug/l	4	145.2	354.0	235.4	86.837
TM Al	ug/l	4	312.6	378.8	339.2	32.253

TABLE 3-8. TOTAL STREAM WATER CHEMISTRY FOR SEVENTH LAKE INLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	103	4.6	6.7	5.6	0.590
Cond	uS/cm	103	26.1	42.0	33.4	3.199
ANC	ueq/l	103	-17.6	145.7	23.8	30.621
Ca	ueq/l	75	107.8	195.2	148.7	21.554
Mg	ueq/l	75	31.8	63.5	47.1	8.933
K	ueq/l	75	5.8	15.8	9.8	2.307
Na	ueq/l	75	20.4	45.8	30.7	6.701
Cl	ueq/l	54	9.4	16.2	11.5	1.822
NO_3	ueq/l	54	10.0	86.2	48.9	22.787
SO_4	ueq/l	54	131.6	183.7	153.2	16.783
SiO_2	umoles/l	61	11.2	165.2	100.2	27.499
DOC	ueq/l	98	19.1	86.2	46.1	11.788
DIC	mg/l	47	0.0	1.1	0.4	0.218
NH_4	ueq/l	61	-0.6	14.1	2.6	3.059
TD Al	ug/l	66	164.0	845.6	410.7	129.418
OM Al	ug/l	4	161.7	218.8	200.0	26.426
TM Al	ug/l	4	211.9	296.9	263.6	38.434
O18		11	-13.1	-11.8	-12.6	0.379

TABLE 3-9. BASEFLOW STREAM CHEMISTRY FOR FLY POND OUTLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	11	6.9	7.2	7.1	0.086
Cond	uS/cm	11	41.3	55.2	49.8	4.695
ANC	ueq/l	11	169.3	293.1	250.8	39.694
Ca	ueq/l	11	29.9	287.4	237.9	72.842
Mg	ueq/l	11	62.6	94.0	82.6	10.695
K	ueq/l	11	10.8	14.6	12.8	1.154
Na	ueq/l	11	79.2	101.7	96.1	6.663
Cl	ueq/l	11	33.6	42.8	36.5	2.451
NO_3	ueq/l	11	17.8	50.1	38.4	12.645
SO_4	ueq/l	11	114.3	129.4	121.3	4.594
SiO_2	umoles/l	11	113.7	293.8	204.8	52.913
DOC	ueq/l	11	17.4	34.5	23.8	5.647
DIC	mg/l	5	2.1	3.9	3.0	0.642
NH_4	ueq/l	11	-0.1	14.6	3.2	4.341
TD Al	ug/l	11	71.5	144.3	103.3	22.126
OM Al	ug/l	2	60.8	66.2	63.6	3.818
TM Al	ug/l	2	55.9	84.1	70.0	19.940

TABLE 3-10. EVENT STREAM CHEMISTRY FOR FLY POND OUTLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	25	5.5	6.9	6.2	0.399
Cond	uS/cm	25	30.6	46.6	36.2	4.170
ANC	ueq/l	25	17.0	159.4	66.9	44.869
Ca	ueq/l	25	158.6	263.4	189.9	28.033
Mg	ueq/l	25	40.0	73.2	49.4	8.690
K	ueq/l	25	10.1	19.2	13.6	2.435
Na	ueq/l	25	31.6	92.9	58.2	15.399
Cl	ueq/l	25	21.4	73.2	40.7	13.131
NO_3	ueq/l	25	28.3	86.0	54.6	17.114
SO_4	ueq/l	25	117.4	151.0	131.7	7.147
SiO_2	umoles/l	25	85.3	172.3	113.0	20.640
DOC	ueq/l	25	24.6	50.2	38.6	6.450
DIC	mg/l	25	0.1	2.2	1.1	0.626
NH_4	ueq/l	25	0.0	19.2	4.2	4.340
TD Al	ug/l	25	111.1	409.2	290.3	74.139

TABLE 3-11. BASEFLOW STREAM CHEMISTRY FOR BALD MOUNTAIN BROOK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	11	6.1	6.5	6.3	0.134
Cond	uS/cm	11	21.7	32.0	27.7	4.029
ANC	ueq/l	11	24.8	68.8	43.8	14.665
Ca	ueq/l	11	93.6	139.4	119.1	17.088
Mg	ueq/l	11	35.6	61.2	50.1	9.972
K	ueq/l	11	4.9	8.8	7.2	1.455
Na	ueq/l	11	39.2	54.8	47.7	5.863
Cl	ueq/l	11	7.1	11.4	8.5	1.562
NO_3	ueq/l	11	16.6	53.9	40.1	15.655
SO_4	ueq/l	11	106.0	139.4	125.2	11.801
SiO_2	umoles/l	11	123.1	231.6	167.1	34.865
DOC	ueq/l	11	13.8	27.0	19.4	5.211
DIC	mg/l	5	0.2	1.0	0.5	0.273
NH_4	ueq/l	11	-0.2	3.1	1.0	1.070
TD Al	ug/l	11	84.0	188.1	141.7	35.278
OM Al	ug/l	2	54.7	73.7	64.2	13.435
TM Al	ug/l	2	145.2	164.8	155.0	13.859

TABLE 3-12. EVENT STREAM CHEMISTRY FOR BALD MOUNTAIN BROOK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	17	4.6	5.4	4.9	0.213
Cond	uS/cm	17	24.9	36.4	29.7	4.084
ANC	ueq/l	17	-20.4	5.5	-4.9	7.370
Ca	ueq/l	16	77.8	127.2	103.2	13.025
Mg	ueq/l	17	23.8	41.6	31.6	4.310
K	ueq/l	17	8.1	14.9	10.2	1.932
Na	ueq/l	17	19.4	37.4	26.2	4.587
Cl	ueq/l	17	8.1	10.0	8.9	0.530
NO_3	ueq/l	17	26.8	85.8	57.6	21.783
SO_4	ueq/l	17	119.5	133.5	128.6	3.602
SiO_2	umoles/l	17	70.8	128.2	92.8	14.687
DOC	ueq/l	17	19.8	40.8	30.4	5.564
DIC	mg/l	17	0.1	0.4	0.2	0.078
NH_4	ueq/l	17	0.0	5.4	1.2	1.720
TD Al	ug/l	17	136.2	628.3	475.3	126.311

TABLE 3-13. BASEFLOW STREAM CHEMISTRY FOR BUCK CREEK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	12	5.4	6.0	5.6	0.207
Cond	uS/cm	12	26.2	32.5	29.6	2.183
ANC	ueq/l	12	9.9	31.3	17.7	6.897
Ca	ueq/l	12	113.9	139.8	127.9	9.504
Mg	ueq/l	12	35.8	48.6	42.6	5.342
K	ueq/l	12	6.8	10.2	8.6	0.995
Na	ueq/l	12	36.6	49.9	42.4	4.465
Cl	ueq/l	11	8.9	13.8	10.8	1.576
NO_3	ueq/l	12	16.2	54.2	37.2	16.266
SO_4	ueq/l	12	143.0	162.3	153.2	7.251
SiO_2	umoles/l	11	127.4	158.0	140.8	11.674
DOC	ueq/l	12	21.6	42.1	29.8	7.651
DIC	mg/l	5	0.4	0.7	0.5	0.142
NH_4	ueq/l	12	-0.2	12.1	1.5	3.376
TD Al	ug/l	12	185.5	386.9	299.3	63.349
OM Al	ug/l	3	218.3	354.0	265.4	76.726
TM Al	ug/l	3	312.6	378.8	334.9	38.020

TABLE 3-14. EVENT STREAM CHEMISTRY FOR BUCK CREEK

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	17	4.5	5.2	4.7	0.152
Cond	uS/cm	17	29.4	42.3	35.3	3.943
ANC	ueq/l	17	-30.1	2.3	-14.2	8.047
Ca	ueq/l	16	98.0	137.0	112.8	10.616
Mg	ueq/l	17	26.8	38.8	31.0	3.301
K	ueq/l	17	9.6	17.4	12.4	2.232
Na	ueq/l	17	19.8	33.4	24.6	3.452
Cl	ueq/l	17	10.2	14.2	11.1	1.017
NO_3	ueq/l	17	41.6	100.8	68.0	23.029
SO_4	ueq/l	17	125.5	153.8	137.9	7.585
SiO_2	umoles/l	17	74.2	115.8	87.2	11.135
DOC	ueq/l	17	32.8	64.6	48.4	9.144
DIC	mg/l	17	0.2	0.5	0.4	0.105
NH_4	ueq/l	17	0.0	11.4	1.9	3.087
TD Al	ug/l	17	384.1	823.3	673.1	89.752

TABLE 3-15. BASEFLOW STREAM CHEMISTRY FOR SEVENTH LAKE INLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	11	5.6	6.2	5.8	0.174
Cond	uS/cm	11	26.1	34.4	30.9	3.553
ANC	ueq/l	11	18.3	37.4	25.0	5.923
Ca	ueq/l	11	124.0	158.1	144.4	15.199
Mg	ueq/l	11	40.2	57.1	50.0	7.009
K	ueq/l	11	6.2	10.4	7.5	1.135
Na	ueq/l	11	32.6	41.4	37.4	3.241
Cl	ueq/l	11	9.4	16.2	11.4	2.299
NO_3	ueq/l	11	10.0	43.7	30.6	14.620
SO_4	ueq/l	11	134.2	180.8	163.6	18.768
SiO_2	umoles/l	11	11.2	146.0	107.6	37.097
DOC	ueq/l	11	28.6	47.6	37.1	7.734
DIC	mg/l	5	0.2	0.6	0.4	0.155
NH_4	ueq/l	11	-0.1	7.2	2.3	2.760
TD Al	ug/l	11	164.0	359.3	271.1	53.798
OM Al	ug/l	2	216.3	218.8	217.6	1.767
TM Al	ug/l	2	257.3	288.3	272.8	21.920

TABLE 3-16. EVENT STREAM CHEMISTRY FOR SEVENTH LAKE INLET

Parameter	Units	N	Minimum	Maximum	Mean	Std Dev
Lab pH	SU	20	4.6	5.4	4.9	0.218
Cond	uS/cm	20	27.4	38.0	32.4	3.575
ANC	ueq/l	20	-17.6	12.1	-2.4	8.506
Ca	ueq/l	20	107.8	162.3	132.8	15.644
Mg	ueq/l	20	31.8	48.8	38.6	4.632
K	ueq/l	20	8.1	15.2	11.3	1.969
Na	ueq/l	20	20.4	30.8	23.6	3.009
Cl	ueq/l	20	10.0	12.1	10.8	0.622
NO_3	ueq/l	20	29.6	84.0	54.6	22.653
SO_4	ueq/l	20	131.6	157.7	140.6	7.031
SiO_2	umoles/l	20	69.4	113.5	84.1	10.350
DOC	ueq/l	20	34.2	78.4	54.4	10.025
DIC	mg/l	20	0.0	0.6	0.3	0.115
NH_4	ueq/l	20	0.0	9.2	2.5	2.301
TD Al	ug/l	20	327.7	583.6	494.2	71.721
O18		9	-13.1	-12.4	-12.7	0.290

TABLE 3-17. SYNTHETIC AND NATURAL AUDIT RESULTS FOR pH, ANC, AND SPECIFIC CONDUCTIVITY

pH							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S1	4.40	3	4.43	0.03	0.75	0.02	0.52
S2	6.53	3	6.42	-0.11	-1.64	0.17	2.65
S4	7.49	3	7.50	0.01	0.13	0.46	6.11
FN09	6.83	7	6.94	0.11	1.61	0.07	0.94
FN10	5.15	7	5.19	0.04	0.78	0.05	0.97
DQO							
SYNTHETIC				0.03		0.03	
NATURAL				0.05		0.10	

ANC							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S1	-39.9	3	-39.5	-0.4	1.00	3.22	-8.14
S2	15.0	3	16.9	1.9	12.87	2.70	15.94
S4	140.0	3	141.9	1.9	1.38	1.56	1.10
FN09	152.3	7	157.2	4.9	3.2	9.38	5.96
FN10	-0.8	7	0.7	1.5	186.25	11.92	1737.36
DQO							
SYNTHETIC				2.5	3	2.5	3
NATURAL				5.0	5	3.0	5

Conductivity							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S1	1.4	3	1.96	0.56	40.00	0.26	13.27
S2	17.0	3	16.09	-0.91	-5.35	0.82	5.07
S4	45.5	3	46.52	1.02	2.25	4.74	10.18
FN09	52.1	7	49.95	-2.15	-4.13	1.92	3.85
FN10	23.5	7	22.85	-0.65	-2.76	1.09	4.76
DQO							
SYNTHETIC				1	3	1	3
NATURAL				2	5	2	5

TABLE 3-18. SYNTHETIC AND NATURAL AUDIT RESULTS FOR CHLORIDE, NITRATE AND SULFATE

Chloride							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.80	3	0.76	-0.04	-5.38	0.03	4.28
S3	5.00	3	4.76	-0.24	-4.90	0.11	2.29
S4	15.0	3	15.14	0.14	0.97	0.66	4.34
FN09	3.96	7	3.95	-0.01	-0.35	0.52	6.54
FN10	0.30	7	0.33	0.03	9.33	0.15	45.37
DQO							
SYNTHETIC				0.01	3	0.01	3
NATURAL				0.06	5	0.06	5

Nitrate							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.30	3	0.32	0.02	7.60	0.05	11.49
S4	3.00	3	2.95	-0.05	-1.73	0.37	12.42
S5	6.00	3	6.17	0.17	2.84	0.74	12.02
FN09	1.06	7	1.00	-0.06	-5.99	0.17	17.15
FN10	0.89	7	0.97	0.08	9.90	0.15	15.82
DQO							
SYNTHETIC				0.006	3	0.006	3
NATURAL				0.020	5	0.020	5

Sulfate							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	2.00	3	1.93	-0.07	-3.45	0.02	1.23
S3	6.00	3	5.88	-0.12	-0.02	0.12	1.97
S4	10.00	3	9.92	-0.08	-0.08	0.12	1.22
FN09	6.36	7	6.45	0.09	1.43	0.14	2.18
FN10	5.65	7	5.93	0.28	5.00	0.52	8.69
DQO							
SYNTHETIC				0.06	3	0.06	3
NATURAL				0.40	5	0.40	5

TABLE 3-19. SYNTHETIC AND NATURAL AUDIT RESULTS FOR AMMONIUM, SILICA AND DISSOLVED ORGANIC CARBON

Ammonium							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.10	3	0.10	0.00	0.0	0.03	32.13
S3	0.25	3	0.25	0.00	0.8	0.07	28.08
S4	0.50	3	0.51	0.01	1.8	0.23	44.69
FN09	0.01	7	0.03	0.02	250	0.07	212.72
FN10	0.04	7	0.04	0.00	-7.5	0.03	200.00
DQO							
SYNTHETIC				0.01	5	0.01	5
NATURAL				0.03	10	0.03	10

Silica							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.70	3	0.64	-0.06	-8.86	0.11	16.79
S3	3.00	3	3.11	0.11	3.63	0.12	3.78
S4	7.00	3	6.99	-0.01	-0.20	0.34	4.85
FN09	4.07	6	4.28	0.21	5.11	0.61	14.29
FN10	3.47	7	3.72	0.25	7.29	0.41	11.12
DQO							
SYNTHETIC				0.05	3	0.05	3
NATURAL				0.06	5	0.06	5

DOC							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	2.50	3	2.59	0.09	3.60	0.32	12.06
S3	5.00	3	5.23	0.23	4.60	0.40	7.64
S4	10.00	3	10.24	0.24	2.40	0.98	9.58
FN09	4.42	7	4.11	-0.31	-7.01	0.48	11.58
FN10	3.31	7	3.45	0.14	4.23	0.28	7.90
DQO							
SYNTHETIC				0.1	5	0.1	5
NATURAL				13.3	10	13.3	10

TABLE 3-20. SYNTHETIC AND NATURAL AUDIT RESULTS FOR CALCIUM, MAGNESIUM AND SODIUM

Calcium							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	2.50	3	2.55	0.05	2.00	0.09	3.37
S3	4.50	3	4.53	0.03	0.67	0.32	0.72
S4	7.00	3	7.03	0.03	4.14	0.14	1.94
FN09	5.02	7	5.05	0.03	0.60	0.58	11.51
FN10	1.82	7	1.83	0.01	0.00	0.11	6.11
DQO							
SYNTHETIC				0.01	3	0.01	3
NATURAL				0.07	5	0.07	5
Magnesium							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.50	3	0.554	0.054	10.80	0.072	13.010
S3	0.80	3	0.861	0.061	7.62	0.076	8.932
S4	1.50	3	1.543	0.043	2.87	0.056	3.564
FN09	0.78	7	0.834	0.054	6.92	0.188	22.482
FN10	0.29	7	0.305	0.015	5.17	0.062	20.506
DQO							
SYNTHETIC				0.01	3	0.01	3
NATURAL				0.07	5	0.07	5
Sodium							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.80	3	0.842	0.042	5.25	0.348	41.26
S3	3.50	3	3.646	0.146	4.17	0.650	17.84
S4	6.00	3	6.174	0.174	2.90	0.366	5.92
FN09	2.59	7	2.575	-0.015	-0.58	0.052	2.04
FN10	0.57	7	0.576	0.006	1.05	0.184	31.92
DQO							
SYNTHETIC				0.01	3	0.01	3
NATURAL				0.07	5	0.07	5

TABLE 3-21 . SYNTHETIC AND NATURAL AUDIT RESULTS FOR POTASSIUM AND TOTAL DISSOLVED ALUMINUM

Potassium							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	0.25	3	0.243	-0.007	-0.028	0.06	24.732
S3	0.35	3	0.378	0.028	8	0.176	46.356
S4	0.6	3	0.584	-0.016	-2.67	0.122	20.832
FN09	0.47	7	0.442	-0.028	-5.96	0.028	6.176
FN10	0.32	7	0.320	0	0	0.1	31.362
DQO							
SYNTHETIC				0.01	3	0.01	3
NATURAL				0.07	5	0.07	5

Total Dissolved Aluminum							
Sample	Theoretical Value	N	Observed Mean	Bias	Relative Bias %	Precision	% Relative Precision
S2	50	3	37.83	-12.17	-24.34	12.41	32.84
S4	400	3	374.17	-25.83	-6.46	13.52	3.62
S5	750	3	730.17	-19.83	-2.64	74.34	9.9
FN09	61	6	38.85	-22.15	-36.31	12.64	32.54
FN10	222	7	167.24	-54.76	-24.66	62.04	38.3
DQO							
SYNTHETIC				6	3	6	3
NATURAL				10	5	10	5

TABLE 3-22. FIELD BLANK SAMPLE RESULTS FOR PARAMETERS ANALYZED FROM NOVEMBER 1988 THROUGH 30 JUNE 1989

Parameter	N	Mean	Min.	Max.	Std. Dev.	Median	95% C.I.
Ca	82	0.02 mg/l	-0.05	0.12	0.032	0.01	0.07
Mg	82	0.00 mg/l	-0.01	0.04	0.007	0.00	0.02
Na	82	0.01 mg/l	-0.03	0.38	0.072	0.00	0.08
K	82	0.00 mg/l	-0.03	0.18	0.039	0.00	0.09
Cl	63	0.05 mg/l	-0.05	0.62	0.115	0.03	0.12
NO_3	63	0.04 mg/l	-0.03	0.25	0.057	0.01	0.16
SO_4	63	0.04 mg/l	-0.03	0.15	0.021	0.04	0.05
SiO_2	70	0.18 mg/l	-0.10	7.09	0.851	0.03	0.34
NH_4	69	0.02 mg/l	-0.01	0.22	0.040	0.008	0.121
DOC	105	0.00 mg/l	-0.33	2.72	0.32	0.00	0.31
TD Al	96	0.006 mg/l	-0.009	0.097	0.0148	0.003	0.034
TM Al	5	0.072 mg/l	0.010	0.247	0.1006	0.021	0.247
OM Al	5	0.072 mg/l	0.007	0.242	0.0980	0.074	0.242
Lab pH	119	5.59	4.09	5.87	0.251	5.64	-
ANC	119	0.30 ueq/l	-85.20	21.10	9.27	0.80	-
Spec Cond	113	2.30 uS/cm	0.88	40.80	5.02	1.30	4.8

TABLE 3-23. LRTAP AUDIT SAMPLE RESULTS

Study: Date Received	Parameters: Number Analyzed	Parameters: Biased #	Parameters: Biased (%)	Results: Number Ranked	Results: Flagged #	Results: Flagged (%)	Sum % Biased & Flags Score
L-18 05/10/88	6	3	(50.0)	60	2	(3.0)	53.0
L-19 09/28/88	5	2	(40.0)	50	1	(2.0)	42.0
L-20 01/05/89	13	1	(7.7)	129	15	(11.6)	19.3
L-21 04/21/89	14	1	(7.1)	140	6	(4.3)	11.4

Validation results from EMSL-LV and EPA Corvallis for stream and snow core chemistry data from July 1988 through June 1989 indicated that less than one-half of one percent of the data were flagged. Approximately half of the flagged data was attributed to road salt contamination in samples collected at Fly Pond Outlet.

3.4 Biology

Biological activities occurring during fall 1988 and spring 1989 included population estimates, fish stocking, "in-situ" bioassays and radiotelemetry experiments. The timing of these activities in relation to stream flow and pH are provided in Figure 3-22. Other biological activities included spatial fish population surveys and macroinvertebrate collections.

3.4.1 Fish Community Associations with Study Streams

The initial fish community structure within the four study streams was evaluated in September 1988 (Table 3-24). Brook trout were observed inhabiting all the study streams, with Fly Pond Outlet having the largest brook trout population. Other fish collected during the initial surveys were creek chub, *Semotilus atromaculatus*; central mudminnow, *Umbra limi*; brown trout, *Salmo trutta* and blacknose dace. Buck Creek exhibited the least number of brook trout but had more fish species present. It should be noted, however, that all fish species caught in Buck Creek were present in the lower section immediately above the lake. The total fish biomass ranged from 0.41 g/m^2 in Buck Creek to 3.48 g/m^2 in Fly Pond Outlet.

During June 1989, fish populations were examined below and above each study reach for relative abundance and species composition. Qualitative electroshocking surveys were conducted on 100 m sections above and below each designated study reach. Generally, fish populations in these areas were similar to the community structure occurring within the study reaches (Table 3-25).

Fish were not present above the study reaches in Bald Mountain Brook and Buck Creek. However, fish were found inhabiting the downstream reaches of both streams below the study sites. Brook trout, mudminnows and darters, *Etheostoma spp.* were collected in the lower section of Buck Creek. The downstream section of Bald Mountain Brook (below the Fly Pond Outlet/Bald Mountain Brook confluence area) contained brook trout, pumpkinseed sunfish, *Lepomis gibbosus*; brown bullhead, *Ictalurus nebulosus*; darter, creek chub, white sucker, *Catostomus commersoni* and blacknose dace. The presence of blacknose dace in this area was the result of stocking in the

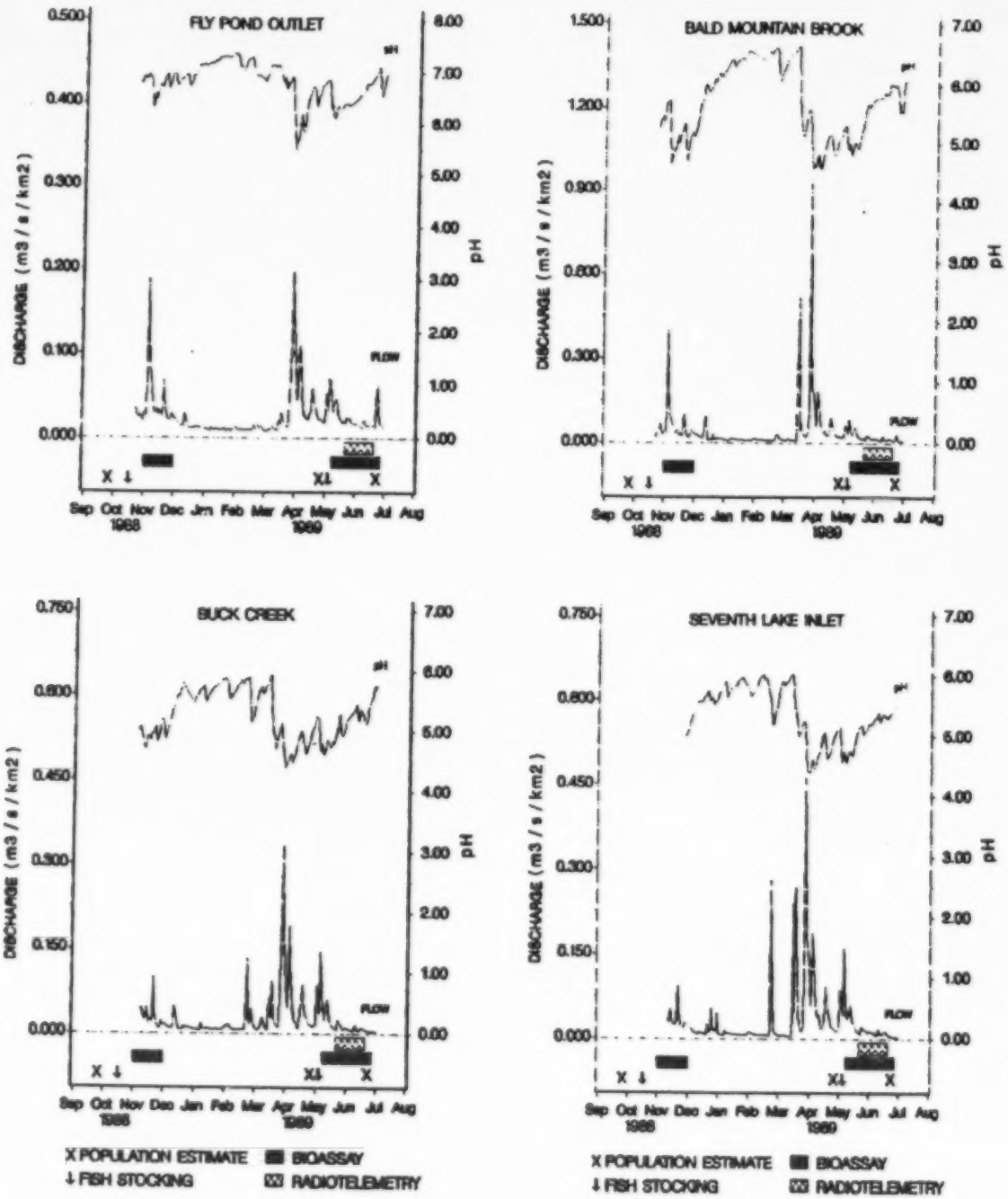


Figure 3-22. Biological activities in relationship to stream flow and pH at the four study streams from October 1988 to July 1989.

TABLE 3-24. INITIAL FISH COMMUNITY STRUCTURE IN STUDY STREAMS INCLUDING BROOK TROUT (ST), CREEK CHUBS (CC), BROWN TROUT (BT), BLACKNOSE DACE (BND), MUDMINNOW (MM) AND LAKE TROUT (LT)

Stream	Spp.	Total #	95% C.I	#/0.1Ha	Total Wt (gm)	g/m2	Total Biomass g/m2
FPO	ST	179	179-184	515.8	1198	3.45	3.48
	CC	2		5.8	10	0.03	
BMB	ST	36	36-43	162.2	320	1.44	1.45
	CC	1		4.5	2	0.01	
BCK	ST	2	2-7	3.9	135	0.26	0.41
	BT	1		1.9	20	0.04	
	CC	4		7.8	34	0.06	
	MM	5		9.8	19	0.04	
	BND	3		5.8	6	0.01	
SLI	ST	36	36-43	48.5	835	1.12	1.20
	MM	3		4.0	12	0.02	
	LT	1			41	0.06	

TABLE 3-25. QUALITATIVE ASSESSMENT OF FISH POPULATIONS BELOW AND ABOVE DESIGNATED STUDY REACHES

Study Reach	Location Site #	Species	Number Captured	Relative Abundance %
Fly Pond Outlet	50-60 (above)	brook trout	23	100.0
Bald Mtn Brook	175-185 (above)		0	
	95-105 (below)	brook trout	22	52.4
		yellow perch	9	21.4
		pumpkinseed sunfish	8	19.0
		brown bullhead	1	2.4
		blacknose dace	1	2.4
		creek chub	1	2.4
Buck Creek	44-54 (above)		0	
	3-10 (below)	brook trout	2	40.0
		central mudminnow	2	40.0
		darter (sp)	1	20.0
Seventh Lake Inlet	105-115 (above)	brook trout	17	100.0
	55-60 (below)	brook trout	15	65.2
		tesselated darter	7	30.4
		central mudminnow	1	4.3

above study reaches.

The stream sections located immediately above Fly Pond Outlet and Seventh Lake Inlet study reaches contained only brook trout. Brook trout, mudminnows and darters were found in the area below the Seventh Lake Inlet study reach. Brook trout were the most abundant species found in all areas upstream or downstream from study reaches.

3.4.2 Bioassays

Thirty-day bioassay experiments were conducted in each of the study streams during the fall of 1988 and again in late spring 1989. Native brook trout and blacknose dace were used as experimental fish. A brook trout bioassay using hatchery reared fry was conducted in the spring of 1989. Results of the two bioassay experiments are summarized for survival, stream discharge, pH and total dissolved aluminum for all study streams in Figures 3-23 through 3-26.

Following start-up of the fall bioassay tests, three of the study streams sustained high fish mortality apparently related to low pH and high aluminum values associated with an episode that occurred just prior to the experiment. Some brook trout mortality was observed in Fly Pond Outlet during this same period, but within the acceptable mortality limit for restart (10%). Total dissolved aluminum ranged between 200 ug/l and 400 ug/l.

During the fall bioassay experiment, the lowest pH values occurred in Buck Creek and Bald Mountain Brook remaining below 5.0 for most of the test period. Total dissolved aluminum in Buck Creek ranged between 550 ug/l and 840 ug/l. During this period, mortality for blacknose dace in Buck Creek was 80 percent, while a 50 percent mortality was observed for brook trout over the initial ten days of the experiment. Mortalities in Bald Mountain Brook during this period were 50 percent for blacknose dace and 38 percent for brook trout. Total dissolved aluminum in Bald Mountain Brook ranged between 360 ug/l and 560 ug/l.

Similar low pH and elevated levels of total dissolved aluminum were recorded for Seventh Lake Inlet. Results of the fall 1988 bioassay experiment indicated a 50 percent mortality occurring within eight days for blacknose dace and 20 percent mortality for brook trout after fifteen days of exposure.

Following a major spring event, bioassay experiments were conducted during a period of low pH (<5.0) and high total dissolved aluminum. Total dissolved aluminum values in Buck Creek reached as high as 700 ug/l.

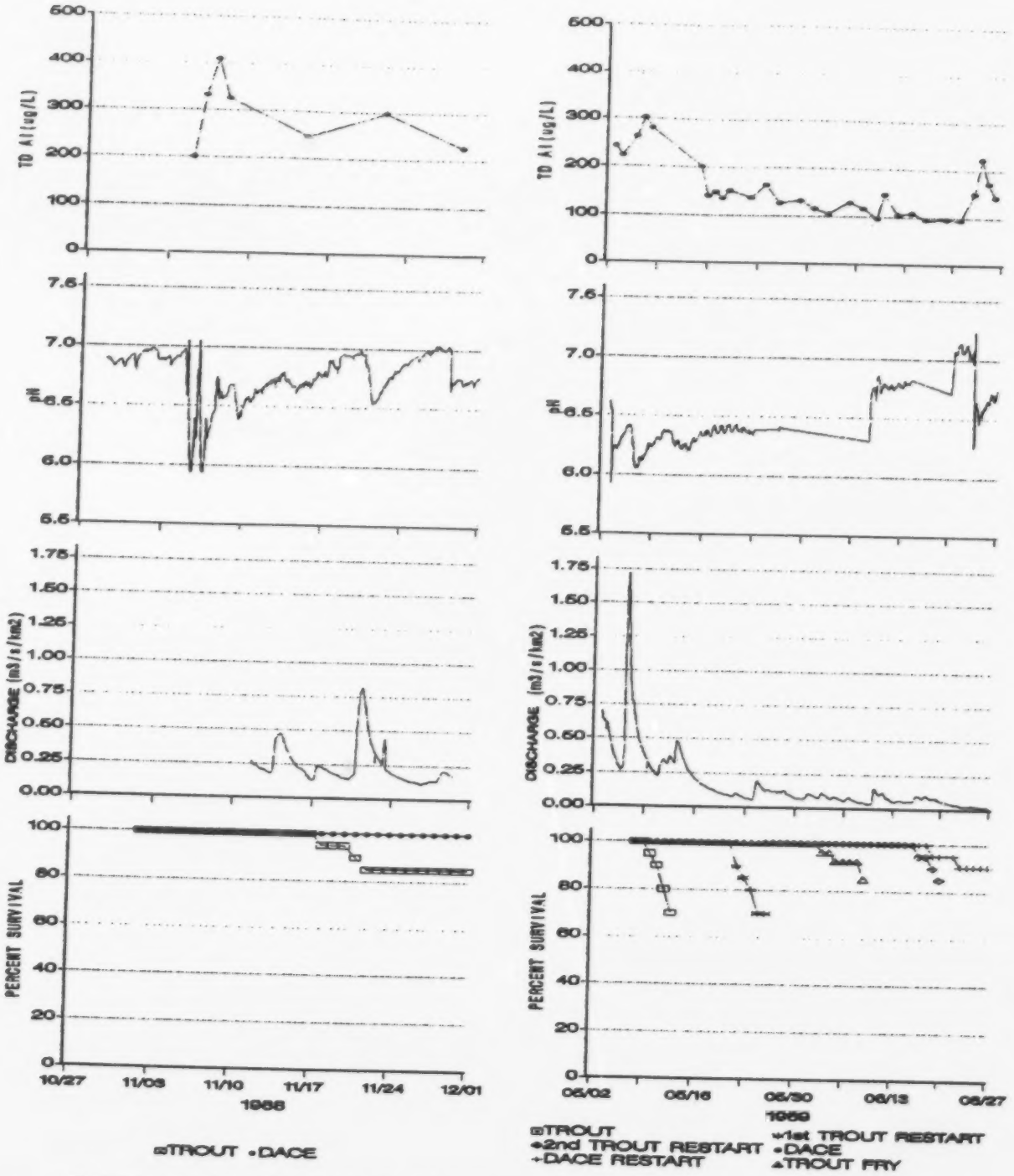


Figure 3-23. Results of bioassay studies conducted at Fly Pond Outlet during fall 1988 and spring 1989 with associated stream discharge, pH and total dissolved aluminum.

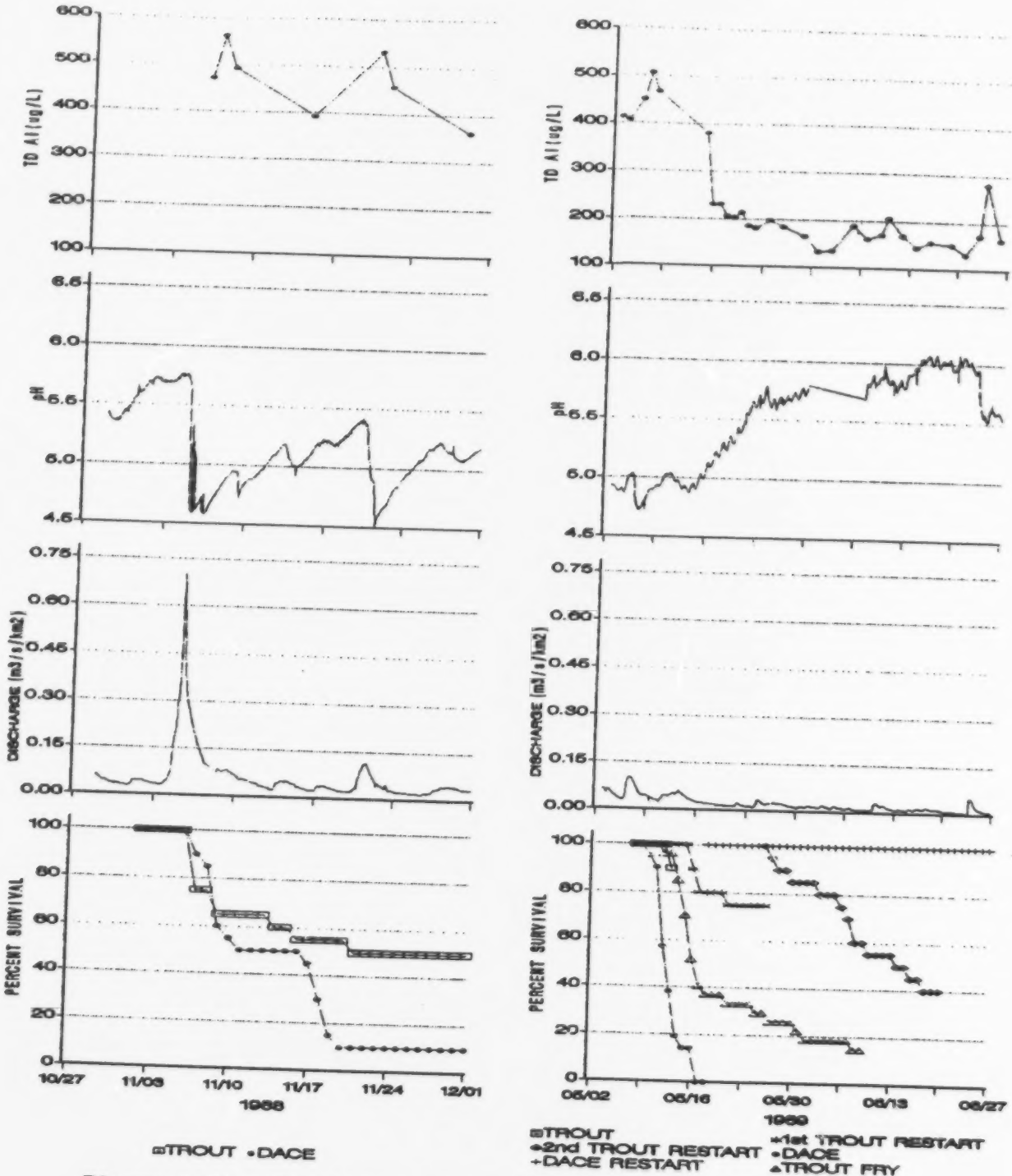


Figure 3-24. Results of bioassay studies conducted at Bald Mountain Brook during fall 1988 and spring 1989 with associated stream discharge, pH and total dissolved aluminum.

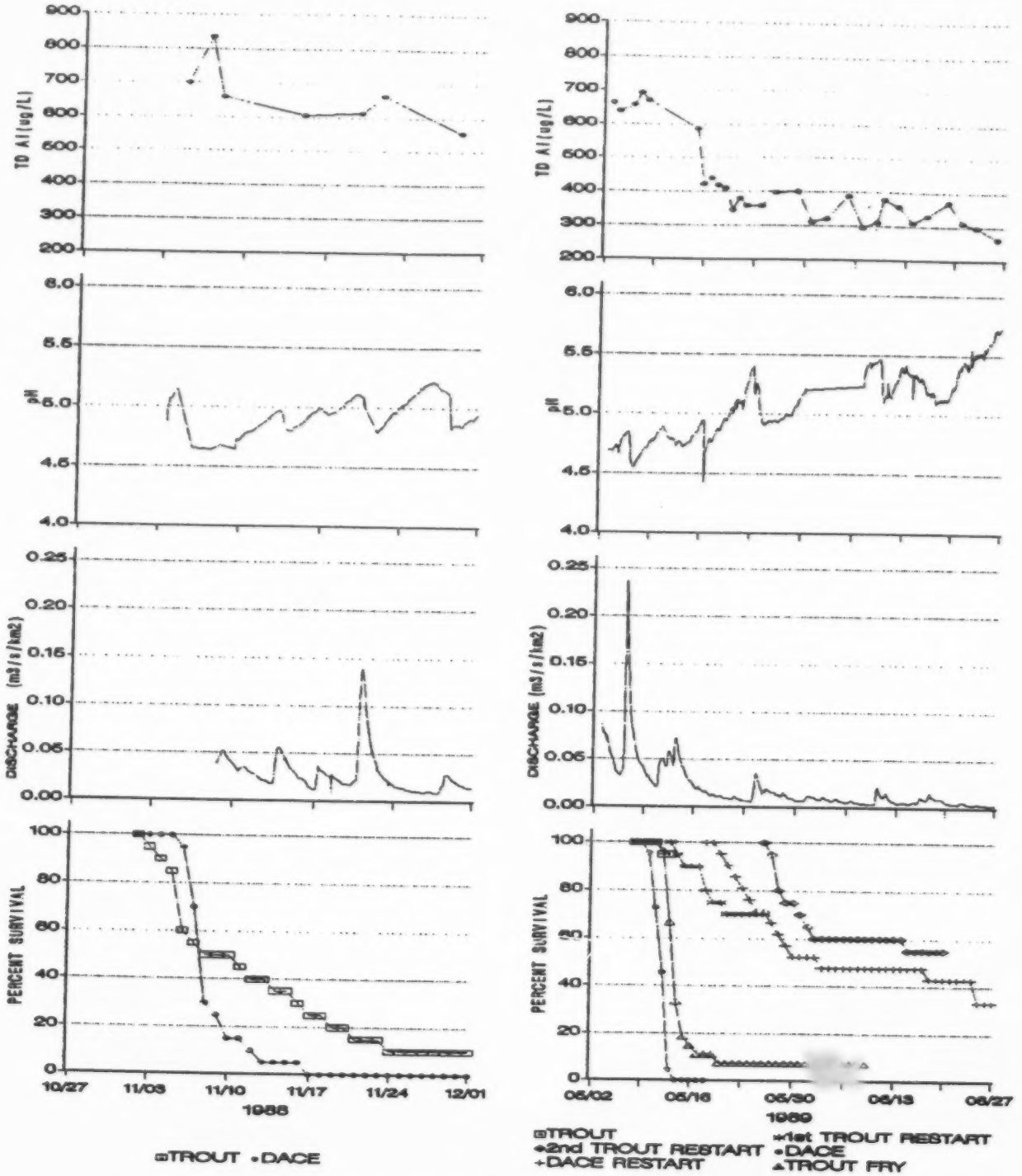


Figure 3-25. Results of bioassay studies conducted at Buck Creek during fall 1988 and spring 1989 with associated stream discharge, pH and total dissolved aluminum.

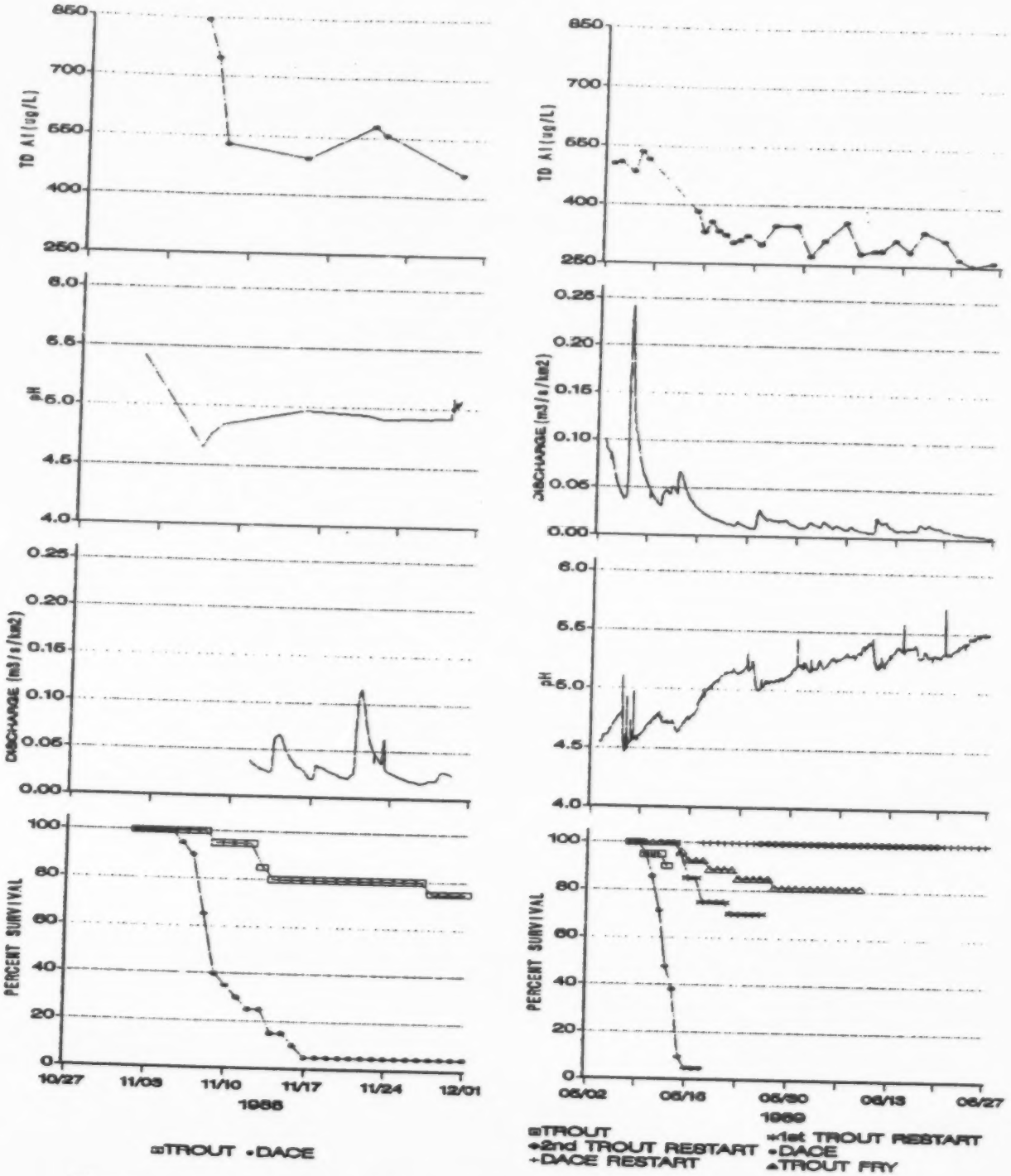


Figure 3-26. Results of bioassay studies conducted at Seventh Lake Inlet during fall 1988 and spring 1989 with associated stream discharge, pH and total dissolved aluminum.

As bioassay experiments progressed, stream chemical conditions appeared to improve (increased pH and decreased aluminum) and reduced mortality was observed.

The bioassay tests involving native brook trout were restarted twice as a result of exceeding the 10 percent mortality limit that occurred in the control stream. The blacknose dace bioassay was also restarted, following a 90 percent mortality that occurred during the first eight days of the experiment in Bald Mountain Brook, Buck Creek and Seventh Lake Inlet.

Based on the bioassay experiments, blacknose dace appeared more sensitive to chemical changes occurring in these streams than did hatchery fry and native brook trout. Blacknose dace did not survive with stream pH equal to 5.0 or lower. Hatchery fry were more sensitive than native brook trout and appeared to show some sensitivity to low pH and high total dissolved aluminum. Brook trout life stage may account for observed differences in mortality between adults and hatchery fry. However, since the native brook trout experiments were restarted due to control stream mortality, these results may be suspect.

3.4.3 Fish Movements

3.4.3.1 Radiotelemetry

The radiotelemetry experiment was initiated in Fly Pond Outlet and Seventh Lake Inlet on 23 May 1989 and continued through 22 June 1989. Individual brook trout movements were assessed daily. Results of radiotelemetry experiments were inconclusive since several transmitters functioned intermittently or not at all during the experiment. However, an overall net upstream movement of brook trout in Fly Pond Outlet and Seventh Lake Inlet was observed. The unusual downstream movement that occurred near the end of the experiment in Seventh Lake Inlet was due to one individual. No apparent cause can be related to this movement (Figure 3-27). Unfortunately, this experiment occurred at a time when there were no major changes in pH or total dissolved aluminum. Therefore, fish movement during this period could not be related directly to event chemistry.

3.4.3.2 Fish Traps

Fish traps were operated from October to early December 1988 and again in May of 1989. Figures 3-28 through 3-30 indicate numbers of fish captured in the Fly Pond Outlet and Bald Mountain Brook fish traps.

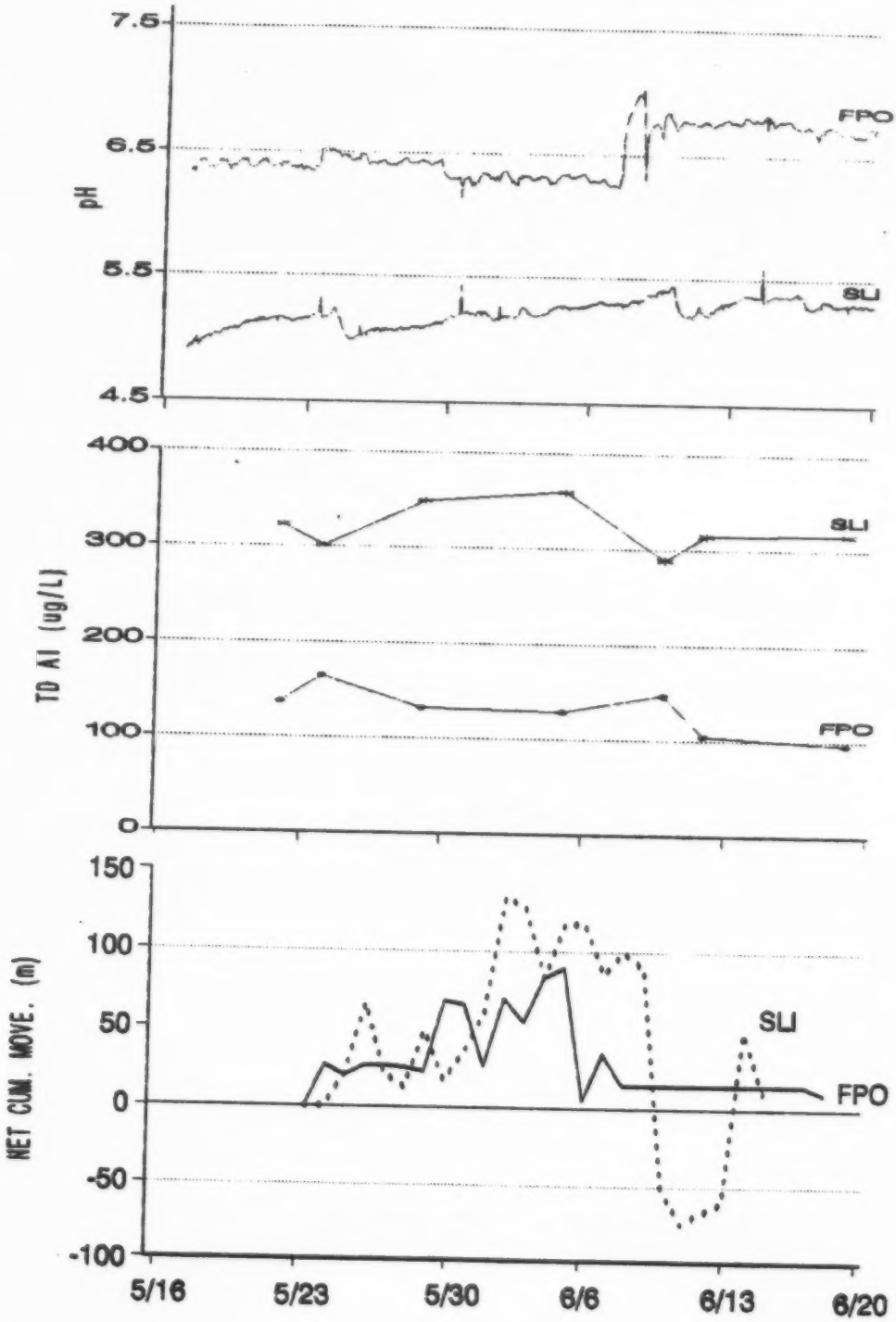


Figure 3-27. Average net cumulative brook trout movement with associated pH and total dissolved aluminum at Fly Pond Outlet and Seventh Lake Inlet, spring 1989.

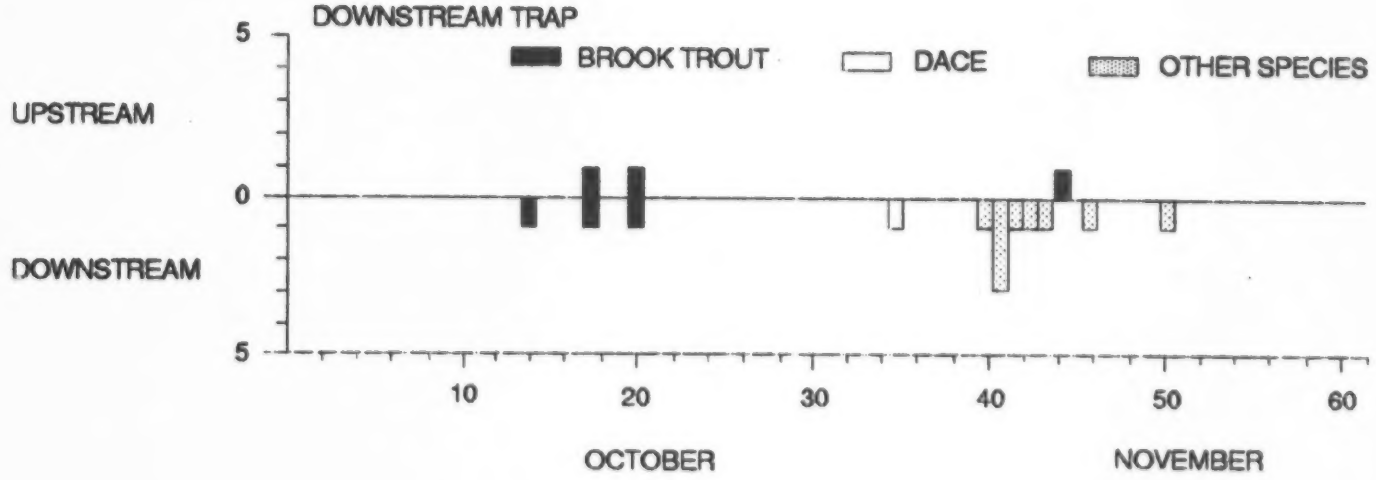


Figure 3-28. Number of fish captured moving upstream or downstream through the lower Fly Pond Outlet fish trap during October and November 1988.

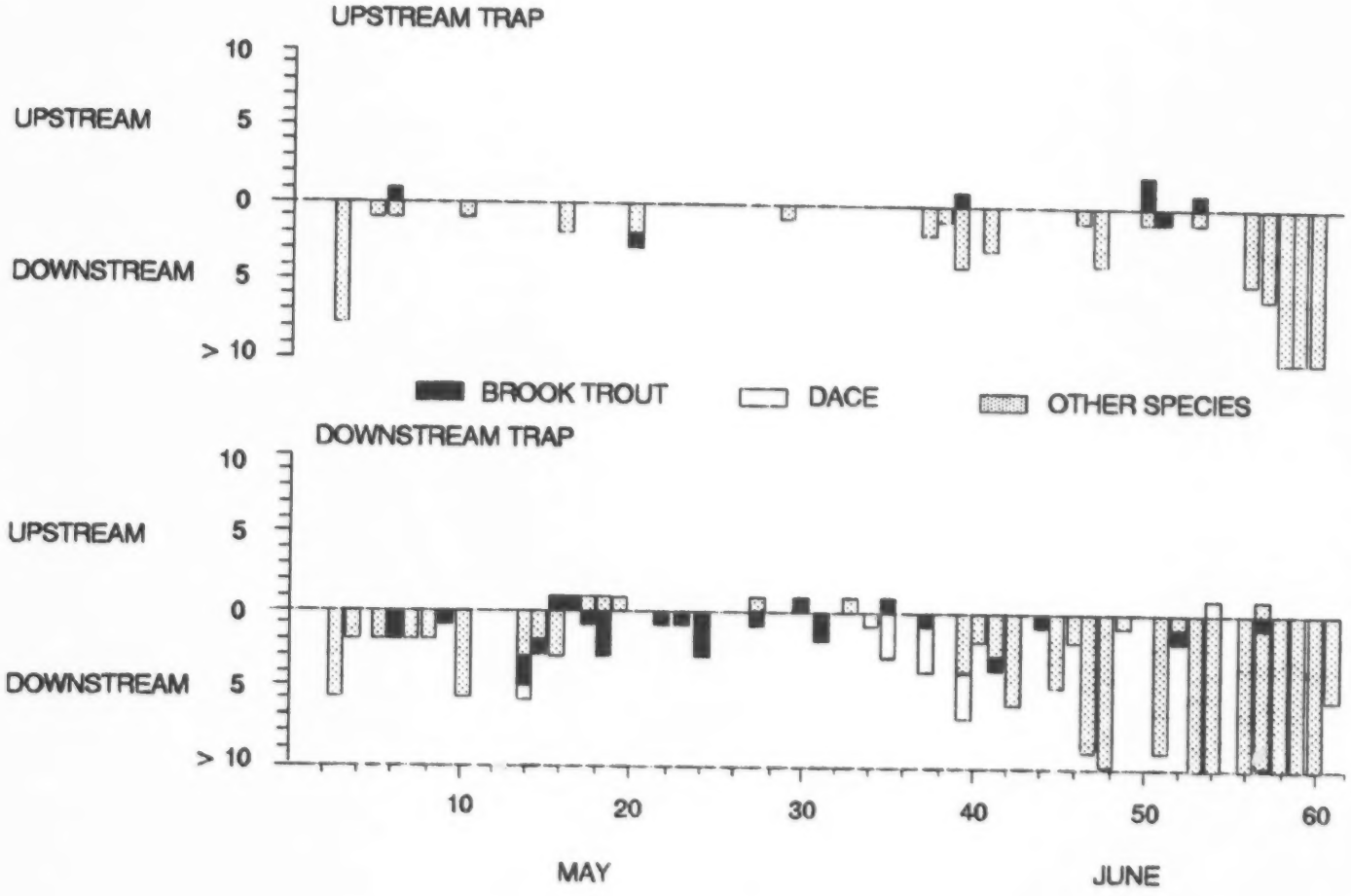


Figure 3-29. Number of fish captured moving upstream or downstream through the upper and lower Fly Pond Outlet fish traps during May and June 1989.

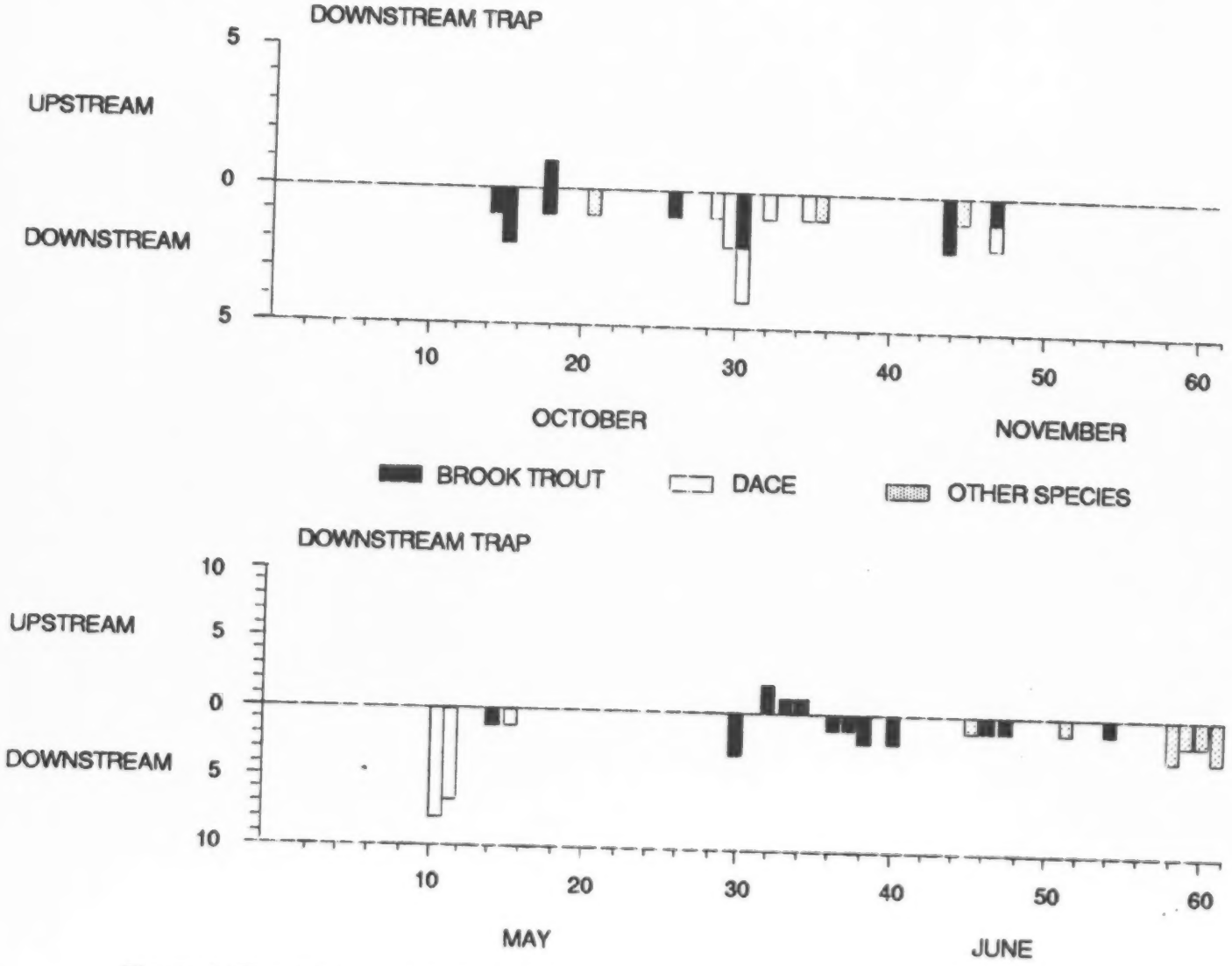


Figure 3-30. Number of fish captured moving upstream or downstream through the Bald Mountain Brook fish trap during fall 1988 and spring 1989.

During the fall of 1988, a total of three brook trout and one blacknose dace were captured moving downstream in the Fly Pond Outlet trap (Table 3-26). In contrast, the Bald Mountain Brook trap captured ten brook trout and eight blacknose dace moving downstream (Table 3-27). Subsequent population estimates conducted in the spring of 1989 were consistent with fall trap data indicating a reduction in the brook trout and blacknose dace in these streams.

No strong relationship of fish movement to stream flow and episodes was observed in Fly Pond Outlet. Yellow Perch were observed periodically moving downstream from Fly Pond during May and June and accounted for 98 percent of the downstream movement observed at this site. In addition, 23 brook trout and 11 blacknose dace moved downstream through the lower Fly Pond Outlet trap in May and June. The majority of blacknose dace in Fly Pond Outlet were not captured moving downstream until baseflow conditions in June.

During the same period, 13 brook trout and 16 blacknose dace moved downstream out of the Bald Mountain Brook trap. The blacknose dace in Bald Mountain Brook were captured in the trap several days following stocking on 11 May during a period when stream pH was approximately 5.0. These fish represented a biomass of 0.19 gm/m^2 or approximately half of the blacknose dace stocked in Bald Mountain Brook. More than 90 percent of the fish movement in Bald Mountain Brook was downstream. Thirty-eight percent of the fish observed in this trap were blacknose dace, 37 percent brook trout, 22 percent creek chubs and two percent white suckers. Although net fish movement was downstream at both sites, the movement in Bald Mountain Brook coincided with hydrologic events in May; whereas, Fly Pond Outlet fish movement occurred mostly during baseflow conditions in June.

Fish movement observed at the fish trap located below the confluence of Fly Pond Outlet and Bald Mountain Brook indicated that 56 percent of the fish were moving downstream. Twenty-eight percent of the fish observed moving downstream were brook trout. Recorded upstream movement at this fish trap involved six unmarked brook trout.

3.4.4 Fish Population

Population estimates for study stream were conducted in October 1988 and again in April and June 1989. The brook trout biomass estimate of 3.45 g/m^2 for Fly Pond Outlet in the fall of 1988 was the highest among study streams. The brook trout biomass estimate in the spring of 1989 was 2.02 g/m^2 reflecting a 42 percent reduction from the fall Fly Pond Outlet estimate. The June estimate indicated a slight increase to 2.12 gm/m^2 which may reflect brook trout growth.

TABLE 3-26. MONTHLY FISH MOVEMENTS THROUGH FISH TRAPS LOCATED ON FLY POND OUTLET FALL 1988 AND SPRING 1989

Species	Month	Upper Trap Downstream Movement	Upper Trap Upstream Movement	Lower Trap Downstream Movement	Lower Trap Upstream Movement
Brook trout	OCT.			3	2
Total				3	2
Brook trout	NOV.				1
Blacknose dace				1	
Yellow perch				7	
White sucker				2	
Total				10	1
Brook trout	MAY	1	1	18	3
Blacknose dace				1	
Yellow perch		15		23	
White sucker		1		2	6
Creek chub				3	1
Total		17	1	47	10
Brook Trout	JUNE	1	4	5	1
Blacknose dace				10	1
Yellow perch		282		503	
White sucker				1	2
Creek chub				1	
Total		283	4	520	4

TABLE 3-27. MONTHLY FISH MOVEMENTS THROUGH FISH TRAPS LOCATED ON BALD MOUNTAIN BROOK FALL 1988 AND SPRING 1989

Species	Month	Lower Trap		Confluence Trap	
		Downstream Movement	Upstream Movement	Downstream Movement	Upstream Movement
Brook trout	OCT.	7	1	2	1
Blacknose dace		5			
Creek chub		1		1	
Total		13	1	3	1
Brook trout	NOV.	3		2	1
Blacknose dace		3		1	
Creek chub		2			
Total		8	0	3	1
Brook trout	MAY	4			1
Blacknose dace		16			
Total		21		4	5
Brook trout	JUNE	9	4	1	5
Yellow perch				2	
White sucker		1		1	
Creek chub		11			
Total		21	4	4	5

Numbers of brook trout per 0.1 hectare decreased during this period (Figure 3-31).

With the exception of Fly Pond Outlet, study streams were stocked in the fall and spring to increase the population densities for brook trout to approximately 2.0 g/m^2 and 0.4 g/m^2 for blacknose dace. The native brook trout population in Fly Pond Outlet was reduced to 1.0 g/m^2 in the spring and replaced with brook trout from source streams in order to approximate stocking and handling stresses that occurred in the other streams. Brook trout removed from Fly Pond Outlet (approximately 354 g) were identified with fin clips and redistributed among the remaining streams. Population estimates and stocking data for streams are provided in Tables 3-28 through 3-31.

Bald Mountain Brook, Buck Creek and Seventh Lake Inlet were stocked with brook trout in the fall of 1988 and again in the spring of 1989. Biomass appeared to decrease following each stocking with the exception of Bald Mountain Brook and Fly Pond Outlet in the spring of 1989 where approximately a 5.0 percent increase was observed for both streams. The greatest biomass loss for brook trout in all streams occurred between the fall of 1988 and spring of 1989. During this period, reductions in brook trout biomass were observed in Fly Pond Outlet (42%), Bald Mountain Brook (40%), Buck Creek (82%) and Seventh Lake (52%) (Table 3-30). Over winter survival of brook trout was lowest in Buck Creek at approximately 18 percent.

Reduction in brook trout biomass estimates between April and late June were noted in Seventh Lake Inlet (26%) and Buck Creek (46%). The increase in biomass of fish observed in Fly Pond Outlet and Bald Mountain Brook from April to June may be related to fish movement into these study reaches (Table 3-31). A number of unmarked fish were observed in each of these areas. The change in the ratio of the marked to unmarked brook trout for the Seventh Lake Inlet and Buck Creek was not as apparent as in the other two streams. However, there was an increase in biomass and numbers of unmarked fish captured in Seventh Lake Inlet (Figures 3-32 and 3-33).

Changes in brook trout abundance and biomass for total and marked fish for each stream including stream discharge and pH from fall 1988 to summer 1989 are provided. (Figures 3-34 through 3-37). Numerous hydrologic events occurred between the initial October stocking date and the April population assessments. These events may have had an influence on the reduced numbers of brook trout observed in the April population estimates.

Blacknose dace populations declined substantially following the 1988 fall stocking in all of the study streams

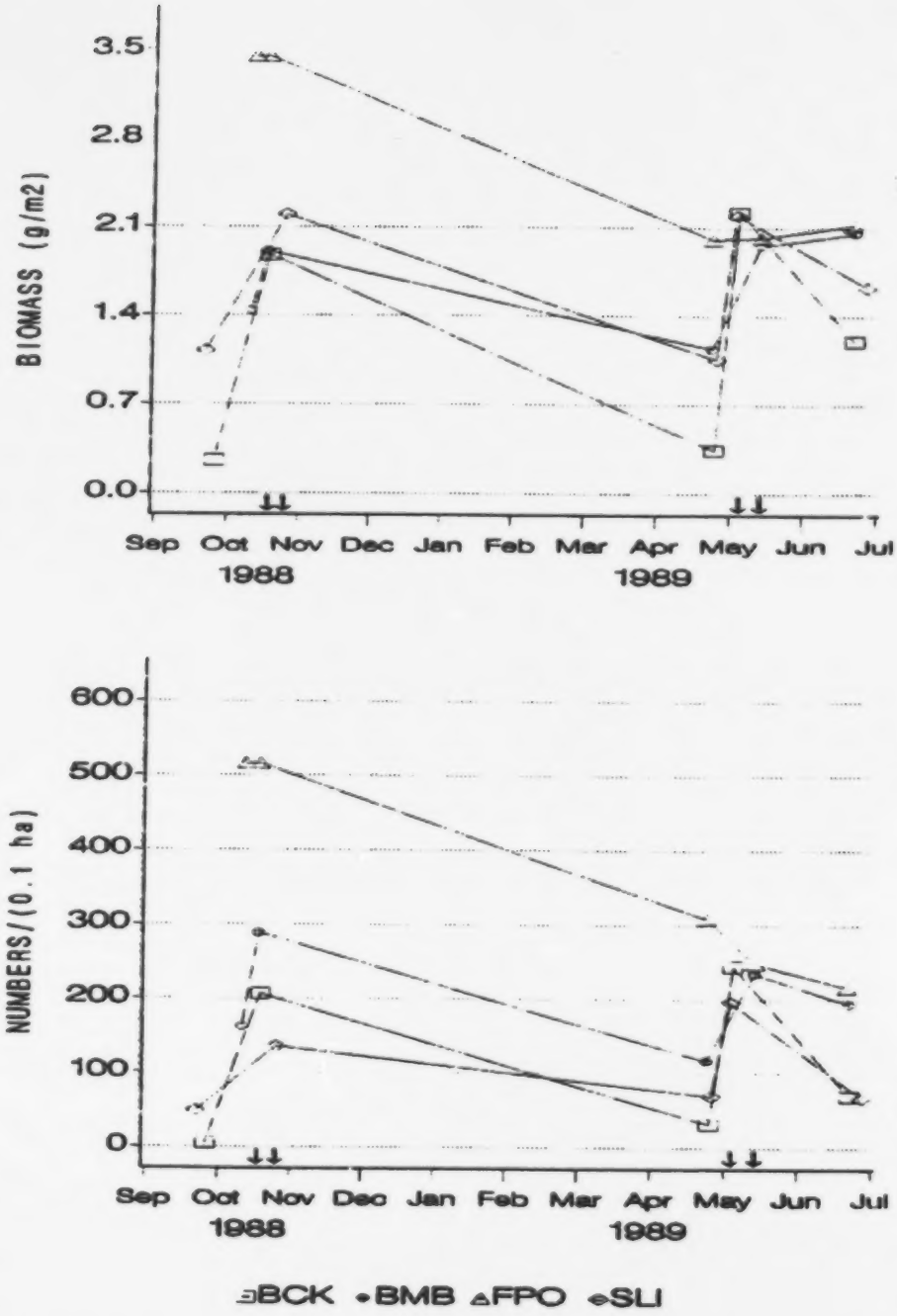


Figure 3-31. Brook trout biomass and numbers during population estimates and following stocking for all study streams (fall 1988 to summer 1989). Arrows denote times of stocking.

TABLE 3-29. SUMMARY OF STOCKING DENSITIES OF BROOK TROUT (ST) AND BLACKNOSE DACE (BND) DURING FALL 1988

Stream	Species	Surface Area (m^2)	Collected		Stocked		Total Wt(g)	g/m^2
			#	Wt(g)	#	Wt(g)		
Fly Pond Outlet	ST	347	179	1198	0	0	1198	3.45
	BND		0		57	154	154	0.44
Bald Mountain Brook	ST	222	36	320a	30	126	423	1.90
	BND		0		30	103	103	0.46
Buck Creek	ST	509	2	135	103	820	955	1.88
	BND		3	3	86	203	206	0.41
Seventh Lake Inlet	ST	742	36	835b	65	804	1635	2.20
	BND		0		123	323	323	0.44

a) Two fish died and 297 g were stocked of the original fish.
b) One fish died and 831 g were stocked of the original fish.

TABLE 3-30. SUMMARY OF STOCKING DENSITIES OF BROOK TROUT (ST) AND BLACKNOSE DACE (BND) DURING SPRING 1989

Stream	Species	Surface Area (m^2)	Collected #	Collected Wt(g)	Stocked #	Stocked Wt(g)	Total Wt(g)	g/m^2	Change in Wt from Fall 1988 (%)
Fly Pond Outlet	ST	347	107	699*	31	354	703	2.02	-42
	BND		21	55	71	103	158	0.46	-64
Bald Mountain Brook	ST	222	26	253	26	183	436	1.96	-40
	BND		0		44	104	104	0.47	-100
Buck Creek	ST	509	16	175a	112	974	1130	2.22	-82
	BND		0	3	113	210	210	0.41	-100
Seventh Lake Inlet	ST	742	51	789b	100	866	1632	2.20	-52
	BND		0		125	323	323	0.44	-100

* FPO population reduced by 51 fish (354 g) and source fish substituted.
a) Two fish died and 297 g were stocked of the original fish.
b) One fish died and 831 g were stocked of the original fish.

TABLE 3-28. POPULATION ESTIMATES OF BROOK TROUT (ST) AND BLACKNOSE DACE (BND) FOR STUDY STREAMS (FALL 1988 - SUMMER 1989)

Stream	Species	Fall			Spring *			Summer **		
		# Collected	Pop.Est.	95% CI	# Collected	Pop.Est.	95% CI	# Collected	Pop.Est.	95% CI
Fly Pond Outlet	ST	179	181	179-184	107	114	107-122	75	77	75-81
	BND	0	0		21	21	21-23	40	41	40-44
Bald Mountain Brook	ST	36	40	36-48	26	27	26-31	43	44	43-47
	BND	0	0		0	0		2		
Buck Creek	ST	2	2	2-7	16	16	16-18	35	36	35-39
	BND	3	3	N/A	0	0		0		
Seventh Lake Inlet	ST	36	38	36-43	51	53	53-58	50	50	50-52
	BND	0	0		0	0		3	5	3-32

* Population estimate includes 1988 fall stocking.

** Population estimate includes 1989 spring stocking.

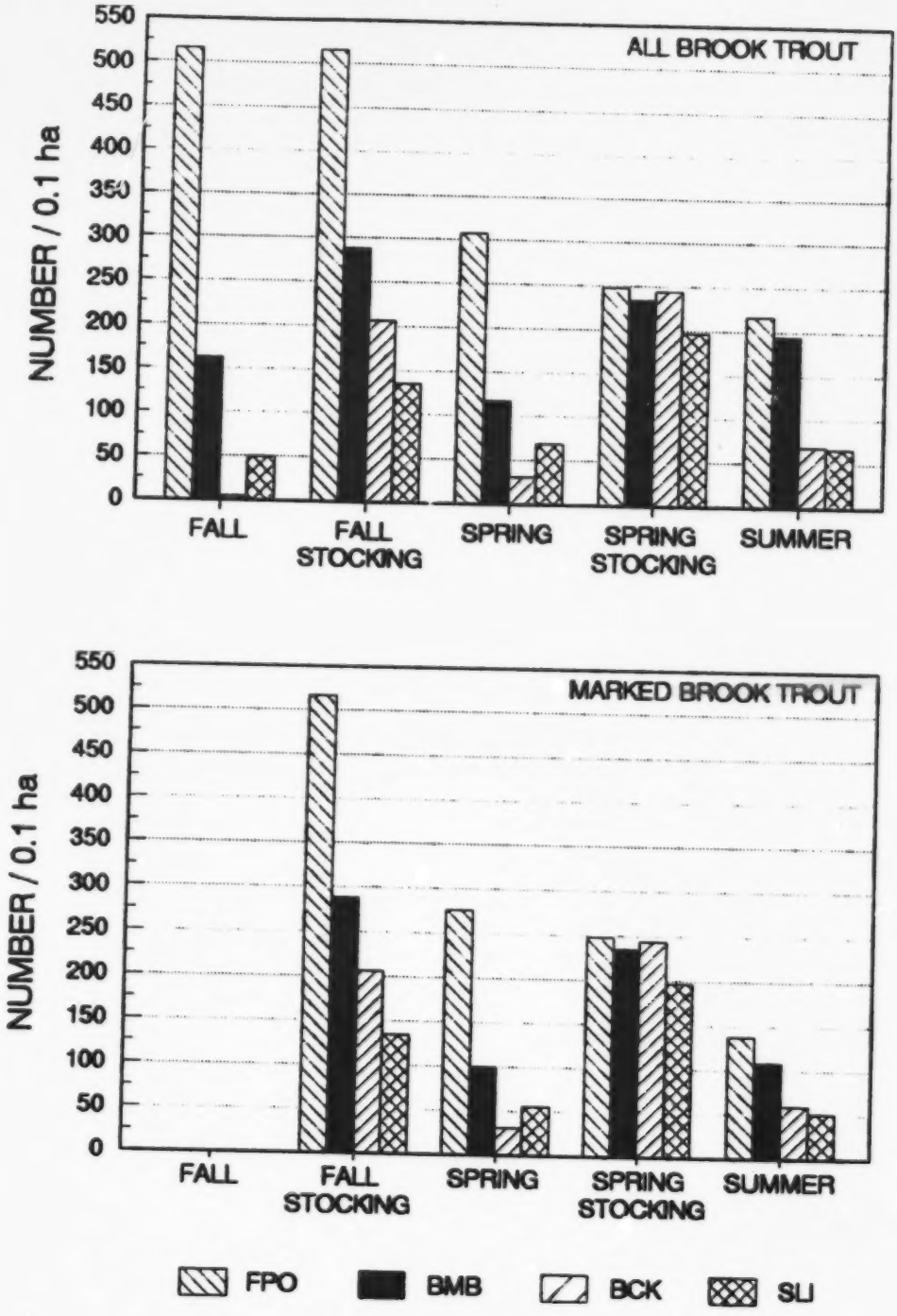


Figure 3-32. Number of all brook trout and marked brook trout present in all study streams from fall 1988 to summer 1989, based on population estimates and stocking data.

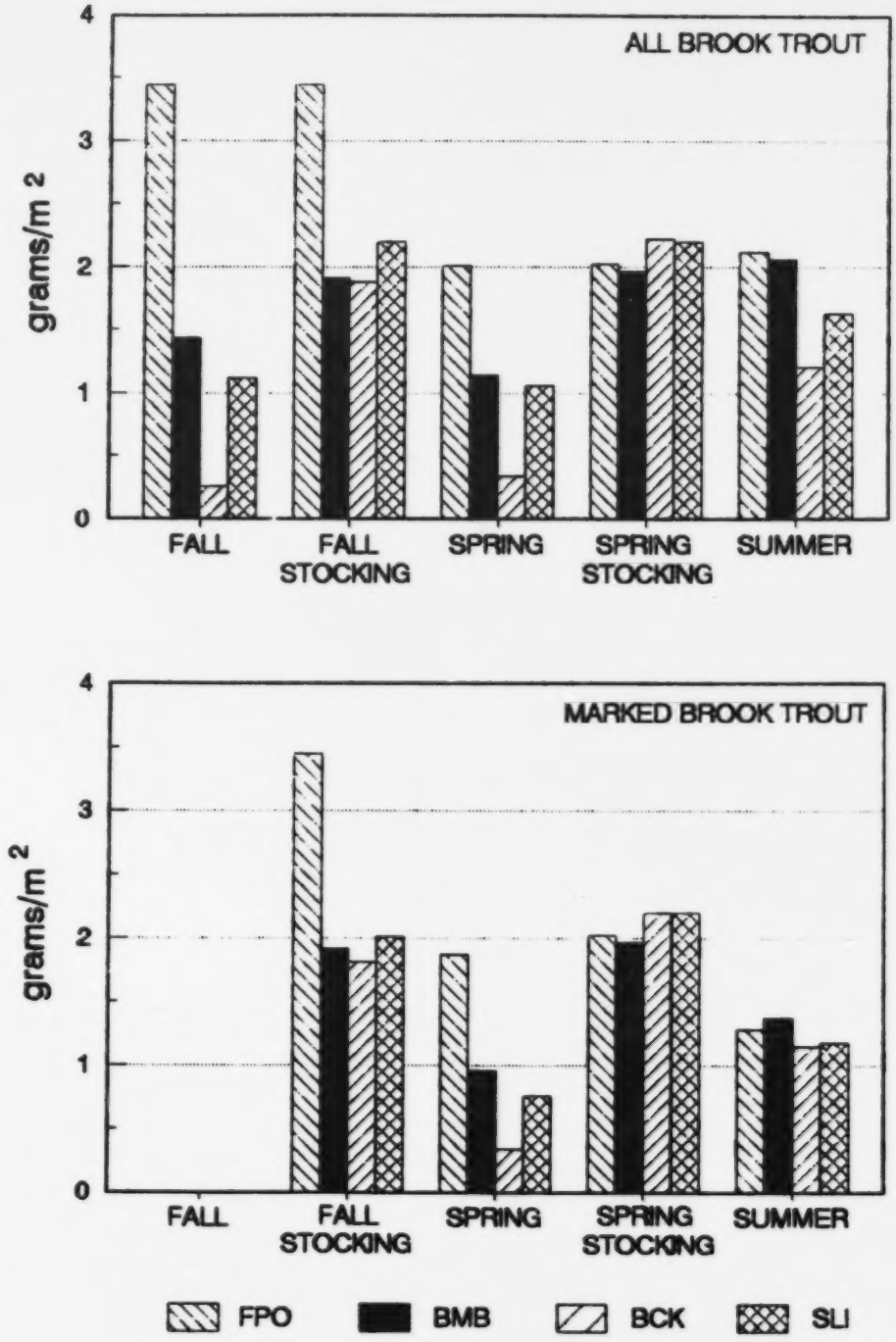


Figure 3-33. Biomass of all brook trout and marked brook trout present in all study streams from fall 1988 to summer 1989, based on population estimates and stocking data.

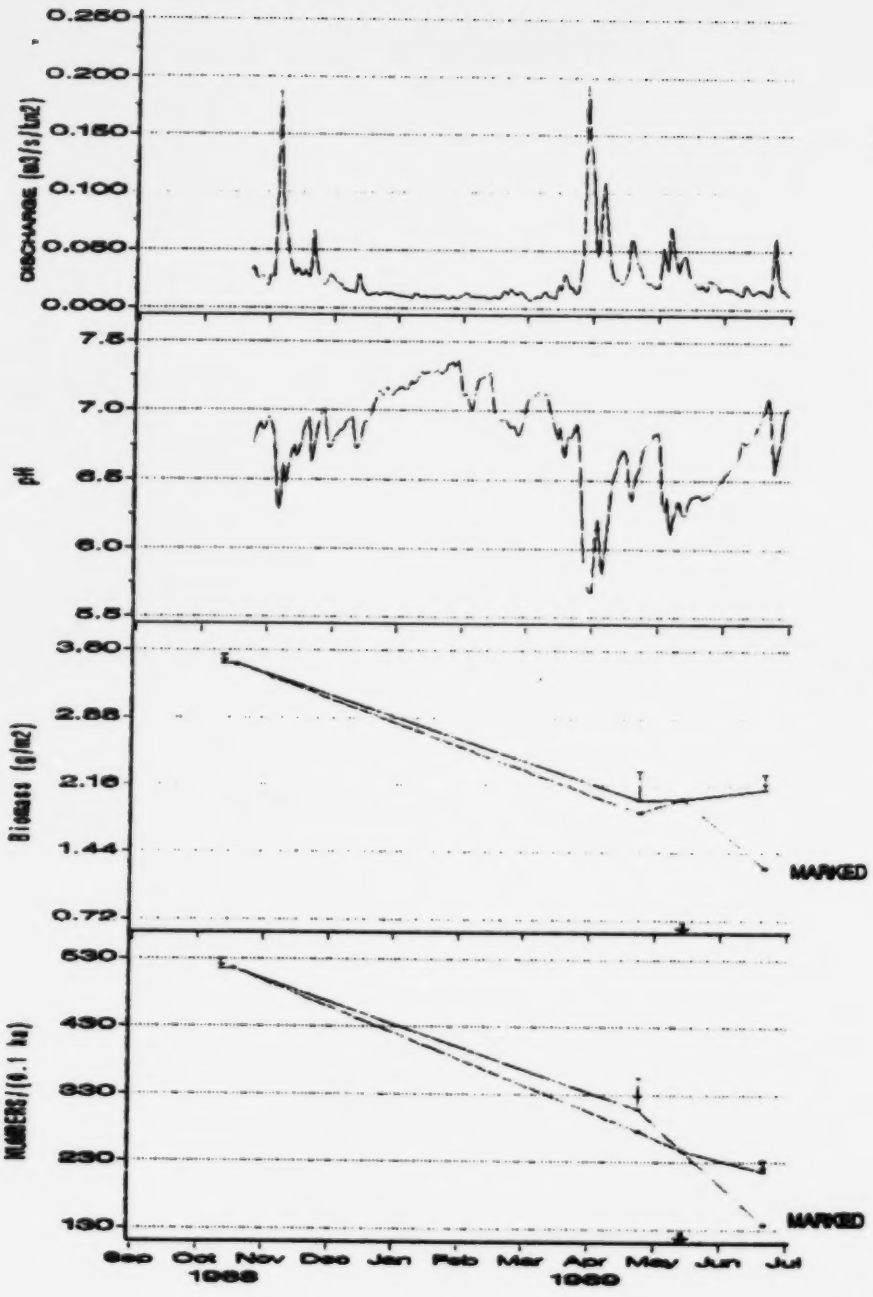


Figure 3-34. Brook trout abundance and biomass for total and marked fish (95% C.I.) in Fly Pond Outlet with associated stream discharge and pH (fall 1988 to summer 1989). Arrows denote date that source fish were added.

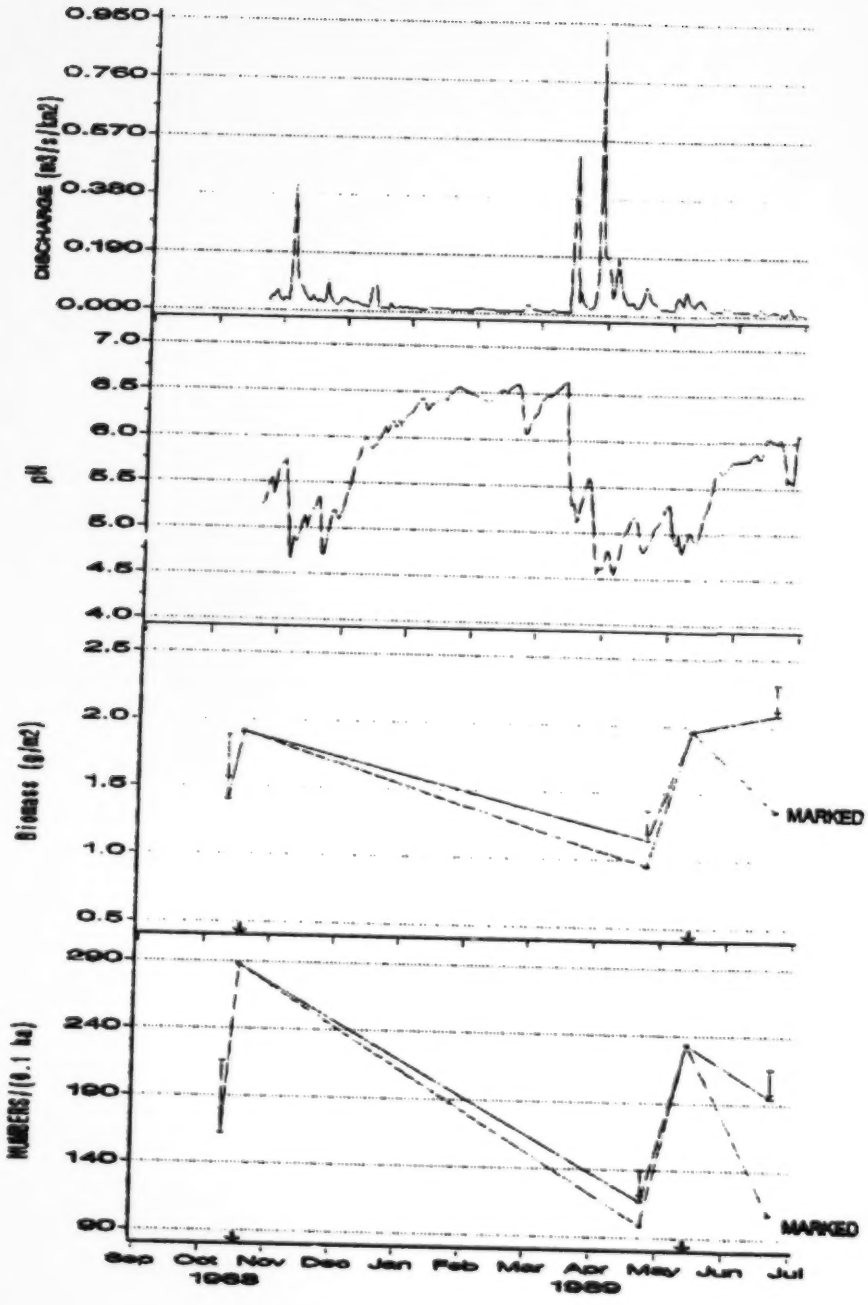


Figure 3-35. Brook trout abundance and biomass for total and marked fish (95% C.I.) in Bald Mountain Brook associated stream discharge and pH (fall 1988 to summer 1989). Arrows denote time of stocking.

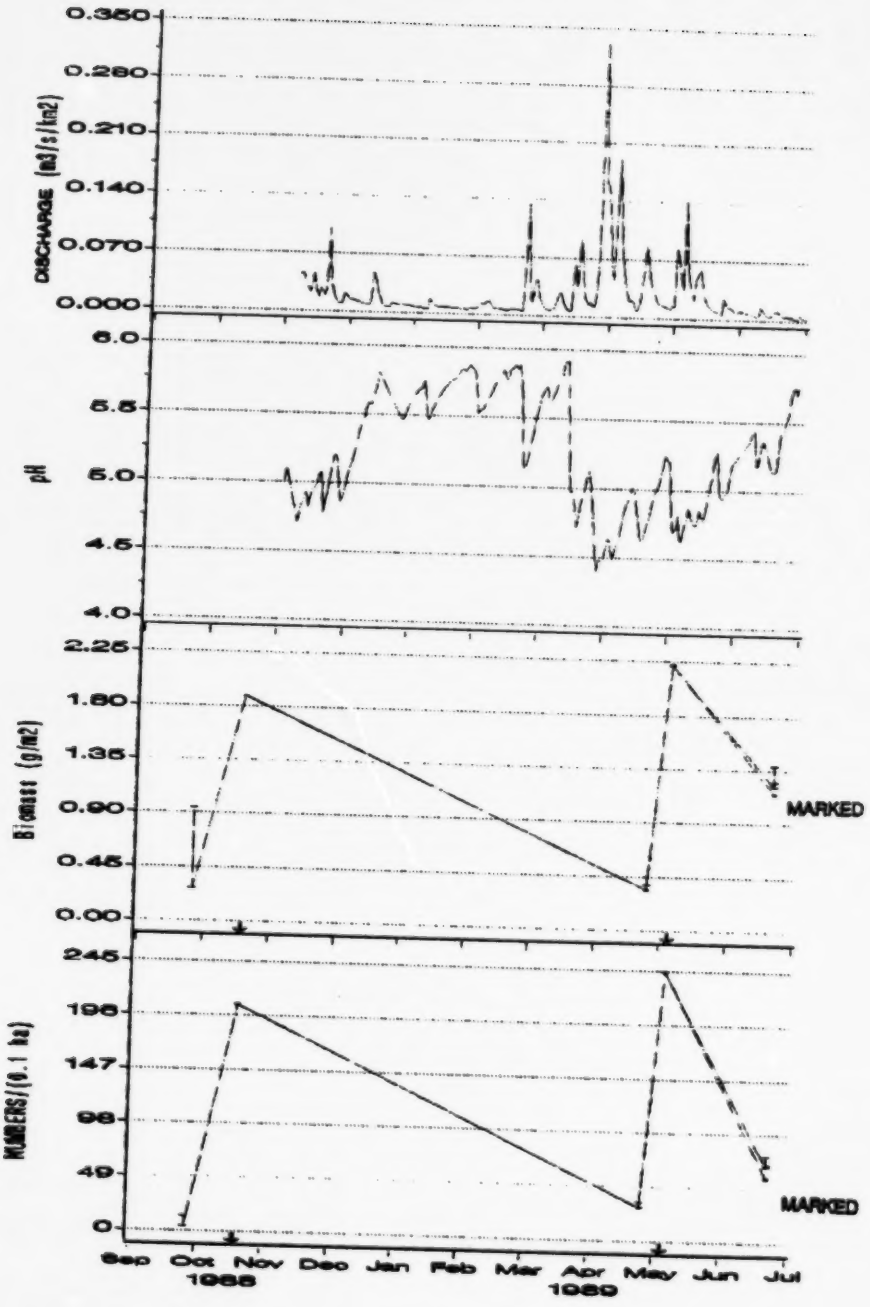


Figure 3-36. Brook trout abundance and biomass for total and marked fish (95% C.I.) in Buck Creek with associated stream discharge and pH (fall 1988 to summer 1989). Arrows denote time of stocking.

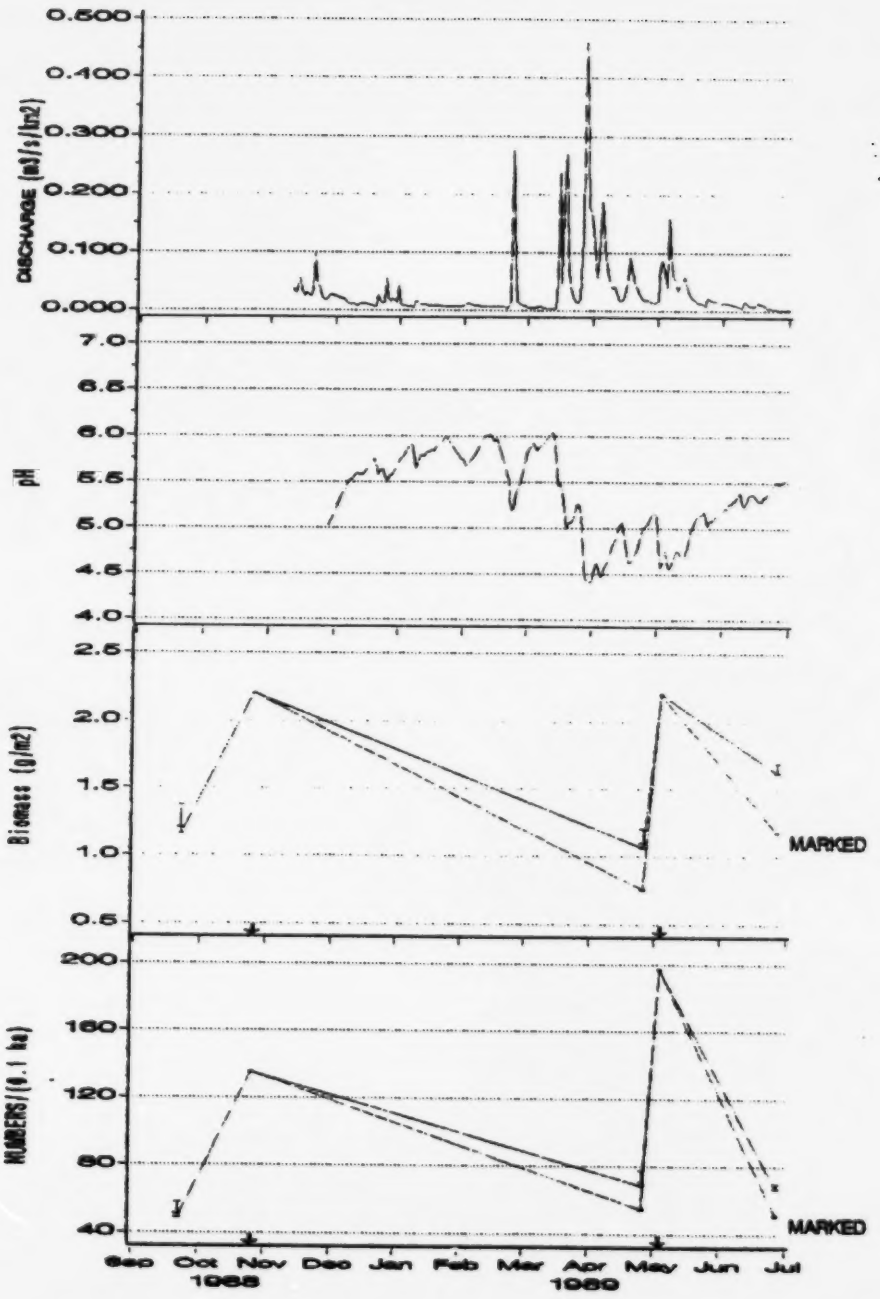


Figure 3-37. Brook trout abundance and biomass for total and marked fish (95% C.I.) in Seventh Lake Inlet with associated stream discharge and pH (fall 1988 to summer 1989). Arrows denote time of stocking.

(Figure 3-38). Carryover of blacknose dace populations occurred only in Fly Pond Outlet with 37 percent of the population remaining in April. Blacknose dace were not collected during the spring population assessment in Bald Mountain Brook, Buck Creek or Seventh Lake Inlet. Recruitment of blacknose dace into the study streams was not apparent.

Blacknose dace were restocked in all streams in May before the 1989 intensive biological studies were initiated. Blacknose dace populations again declined prior to the summer population assessments. Two blacknose dace were found in Bald Mountain Brook and three individuals were found in Seventh Lake Inlet. Forty-three percent (40) of the blacknose dace population remained in Fly Pond Outlet. No blacknose dace were collected in Buck Creek.

An electroshocking survey was conducted to determine the fish population estimate for the section of stream immediately below the confluence of Bald Mountain Brook and Fly Pond Outlet (Table 3-32). This section included the area between the lower fish traps on Fly Pond Outlet and Bald Mountain Brook and the downstream trap on Bald Mountain Brook. A total of 68 brook trout (54 unmarked), 15 blacknose dace and eight creek chubs were found in this section. Eleven of the marked brook trout originated from Bald Mountain Brook and three from Fly Pond Outlet. Seven blacknose dace collected from this section were from Bald Mountain Brook and eight from Fly Pond Outlet.

3.4.4.1 Electroshocking Efficiency

An efficiency check was conducted in June to evaluate the effectiveness of electroshocking operations for determining population estimates. The efficiency check was conducted in a brook trout stream with habitat characteristics similar to the ERP study streams. Blocking seines were placed at the upper and lower end of a stream section approximately 50-100 meters in length. A total of 25 brook trout were captured, marked and released immediately back into the study section. Three consecutive electroshocking passes were completed utilizing the Zippin Method. A total of 45 brook trout were captured, including seventeen marked fish representing a 68 percent efficiency level.

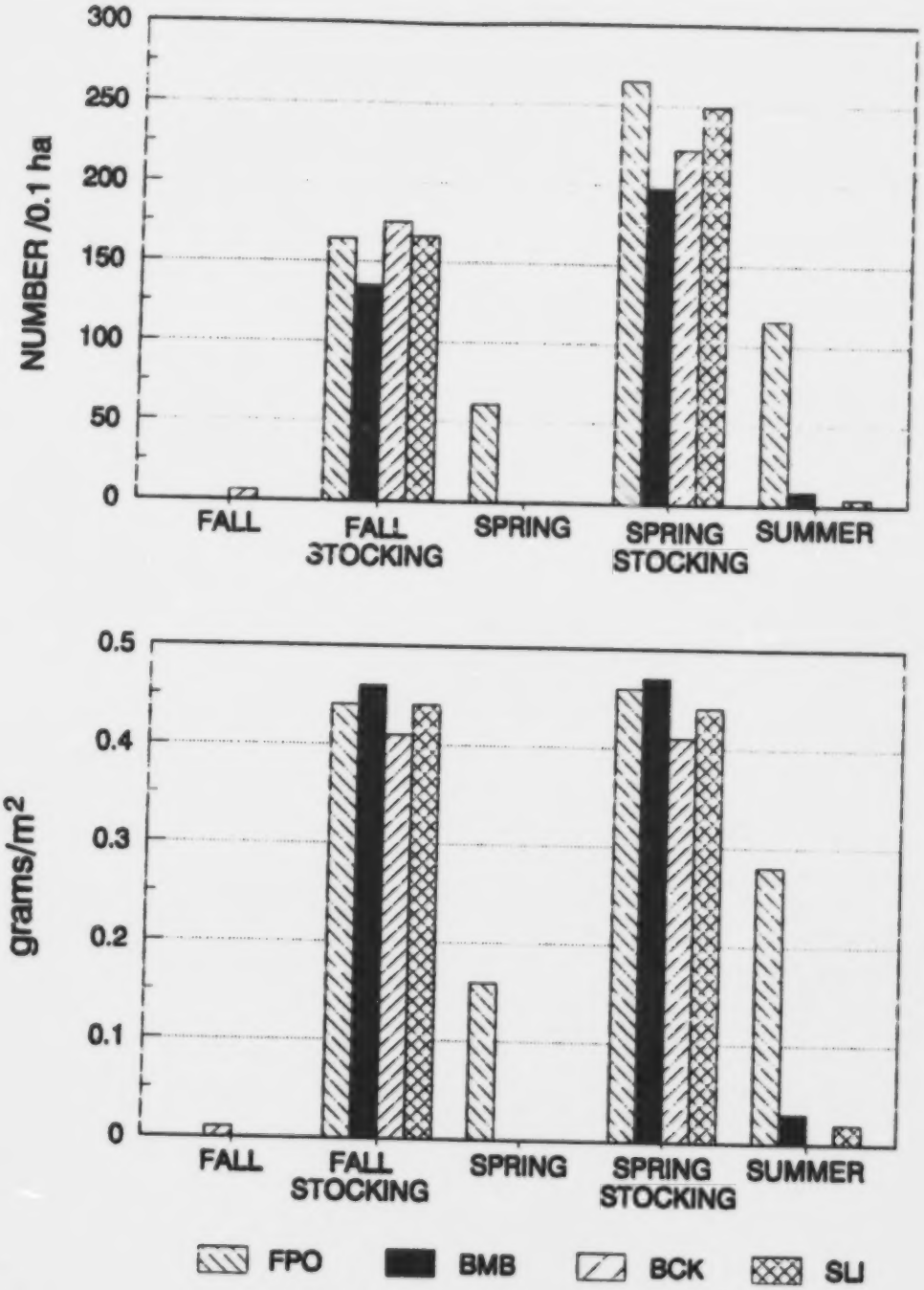


Figure 3-38. Numbers and biomass of blacknose dace in all study streams from fall 1988 to summer 1989, based on population estimates and stocking data.

TABLE 3-32. POPULATION ESTIMATE FOR BROOK TROUT (ST) AND BLACKNOSE DACE (BND) IN THE CONFLUENCE AREA (FAB) BETWEEN FISH TRAPS ON FLY POND OUTLET AND BALD MOUNTAIN BROOK (JUNE 1989)

Site	Species	# Collected	Population Estimate	95% CI
FAB	ST	68	69	68 - 72
	BND	15	17	15 - 24

3.4.5 Macroinvertebrates

A total of 36 macroinvertebrate families representing 14 orders were collected from the four study streams in April of 1989. The number of families collected in replicate samples ranged from three to 21 (Figure 3-39). The largest number of macroinvertebrate families (26) and the greatest number of individuals (2090) were collected from Fly Pond Outlet. The least number of individuals (128) were collected from Seventh Lake Inlet representing 19 families. Bald Mountain Brook had the least number of families represented (18). The orders Diptera, Tricoptera and Plecoptera were abundant in each of the study streams. Ephemeroptera and Coleoptera were most abundant in the control stream with 438 and 225 individuals collected. High populations of Simuliidae were present in Fly Pond Outlet, but were not collected at Bald Mountain Brook. A total of nine families of macroinvertebrates were common to all study streams (Table 3-33).

The number of macroinvertebrate families collected in a stream appeared to be directly related to the chemical conditions found in each stream. Buck Creek, which had the lowest pH and ANC had the least number of Ephemeroptera and Coleoptera present when compared to the other study streams. Ephemeroptera appeared to be the most sensitive to low pH. Similar findings were observed for acidified headwater streams in Pennsylvania (Sharpe et al. 1987). Sharpe et al. (1987) observed increased numbers of Diptera and Trichoptera in severely acidified streams whereas similar findings were not observed in the Adirondack study streams. Increased numbers of Plecoptera were observed in Buck Creek and Bald Mountain Brook, as compared to Fly Pond Outlet for the April sample. A summary of macroinvertebrate taxa collected in the study streams is provided (Table 3-34).

4.0 CONCLUSIONS

Wet deposition occurring in the study area between mid-December 1988 and 30 June 1989 was acidic with a mean volume-weighted concentration of 51.47 ueq/l H^+, equal to a pH of 4.29. During this period, 564.7 mm of precipitation was recorded in the study area at the Moss Lake site. Sulfate and nitrate were the primary anions found in the precipitation. Snow cover was present in the study area during the winter months with a mean snow depth of approximately 45 cm from January through mid-April.

Episodes occurred in each of the study streams and were associated with changes in water chemistry. The greatest stream flow recorded (3.0 m^3/s) for this study

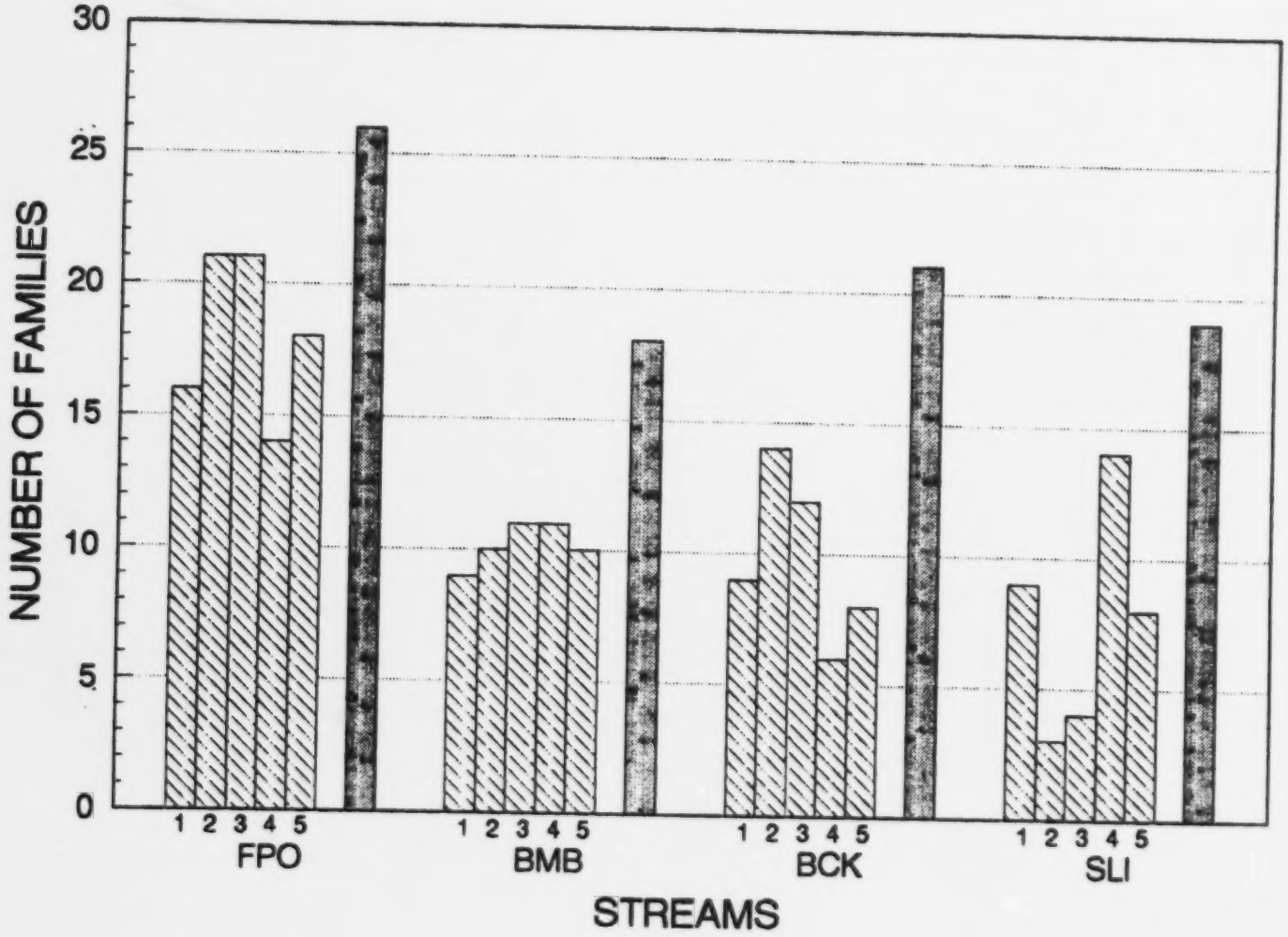


Figure 3-39. Number of macroinvertebrate families collected by replicate samples in Adirondack study streams during April 1989 (solid bar indicates total number of families from replicate samples).

TABLE 3-33. MACROINVERTEBRATE FAMILIES COLLECTED AT THE FOUR STUDY STREAMS DURING APRIL 1989

Order	Family	Fly Pond Outlet	Bald Mountain Brook	Buck Creek	Seventh Lake Inlet	Totals
Amphipoda	Talitridae	0	1	0	0	1
Coleoptera	Elmidae	225	6	3	5	239
Collembola	Isotomidae	0	0	0	2	2
Diptera	Ceratopogonidae	16	9	1	2	28
	Chironomidae	185	89	46	45	365
	Empididae	5	0	6	0	11
	Simulidae	952	0	29	10	991
	Tipulidae	57	2	7	4	70
	unidentified	0	0	1	0	1
Ephemeroptera	Bactidae	228	4	0	0	232
	Ephemerellidae	200	6	1	4	211
	Heptageniidae	10	10	2	3	25
	Leptophlebiddae	0	7	0	0	7
Hydracacina	Libertiidae	1	0	0	0	1
	unidentified	1	0	1	0	2
Lepidoptera	Pyralidae	0	1	0	0	1
Megaloptera	Sialidae	0	6	1	1	8
Odonata	Gomphidae	2	2	0	0	4
Oligochoeta	unidentified	1	0	0	1	2
Pelecypoda	(Sphafriidae prob)	1	0	0	0	1
Plecoptera	Capriidae	2	6	0	0	8
	Chloroperlidae	14	8	1	0	23
	Leuctridae	25	136	139	25	325
	Nemouridae	29	0	18	9	56
	Perlodidae	0	0	0	1	1
Trichoptera	Glossosomatidae	1	0	0	0	1
	Hydropsychidae	10	4	1	2	17
	Hydroptilidae	66	0	0	0	66
	Lepidostomatidae	18	1	10	1	30
	Limnephilidae	29	1	0	1	31
	Molannidae	0	0	1	0	1
	Odontoceridae	2	0	2	7	11
	Philopotamidae	3	0	3	0	6
	Polycentropodidae	0	0	0	2	2
	Rhyacophilidae	7	0	9	3	19
Turbellaria	unidentified	0	0	1	0	1
	TOTALS	2090	299	283	128	2800

TABLE 3-34. SUMMARY OF MACROINVERTEBRATE TAXA COLLECTED IN FOUR ADIRONDACK STUDY STREAMS DURING APRIL 1989.

ORDER	FLY POND OUTLET		BALD MOUNTAIN BROOK		SEVENTH LAKE INLET		BUCK CREEK	
	No.	%	No.	%	No.	%	No.	%
EPHEMEROPTERA	438	21.0	27	9.0	7	5.0	3	1.0
DIPTERA	1215	58.0	100	33.0	61	48.0	90	32.0
TRICHOPTERA	136	7.0	6	2.0	16	13.0	26	9.0
PLECOPTERA	70	3.0	150	50.0	35	27.0	158	56.0
COLEOPTERA	225	11.0	6	2.0	5	4.0	3	1.0
OTHERS	6	0.0	10	3.0	4	3.0	3	1.0
TOTAL	2090		299		128		283	

period occurred during the spring melt at Seventh Lake Inlet, the stream with the largest watershed. Stream flows varied considerably with minimum discharge ranging from 0.001 $m^3/s/km^2$ to 0.005 $m^3/s/km^2$ and maximum discharge during events ranging from 0.23 $m^3/s/km^2$ to 1.67 $m^3/s/km^2$. The most significant event that occurred was the snowmelt in late March and early April. Base flow conditions occurred from early January through mid-February and during June in all study streams.

Water chemistry during base flow conditions was much different when compared to event chemistry. During base flow, pH ranged from 5.37 to 7.25, while during hydrologic events, the pH ranged from 4.50 to 6.99. In general, changes in water chemistry during episodes in Fly Pond Outlet were not as severe as was observed in the other streams. Hydrologic events that occurred in Fly Pond Outlet did not result in as low a pH or as high a total dissolved aluminum value as was observed in Bald Mountain Brook, Buck Creek or Seventh Lake Inlet.

Initial fish population assessments indicated that Fly Pond Outlet had a brook trout population biomass of 3.45 g/m^2, whereas the biomass in the other streams ranged from 0.26 to 1.44 g/m^2. Buck Creek had a total fish biomass of only, 0.41 g/m^2. Young-of-the-year brook trout were only observed in Fly Pond Outlet.

Native brook trout stocked in Buck Creek, Seventh Lake Inlet and Bald Mountain Brook increased the biomass of each stream to 2.0 g/m^2 during the fall of 1988. However, by April 1989, brook trout populations were substantially reduced in all streams. Several events occurred during this period and may have contributed to the reduced brook trout populations found in the spring. Since brook trout were present in the study streams following these hydrologic events, additional research is needed to understand the relationship between events and changes in brook trout populations.

Based on bioassay and population estimate data, it is apparent that blacknose dace are more sensitive to changes in stream chemistry than brook trout. The duration of exposure to acidic stream water may be important in determining whether or not blacknose dace can survive. The episodes which occurred during the fall of 1988 and spring of 1989 appeared severe enough to eliminate the stocked blacknose dace populations in three of the four streams.

The Fly Pond Outlet macroinvertebrate collection had more families and individuals per sample than the other streams. This appeared to be related to the water quality found in Fly Pond Outlet.

Additional analyses of the Episodic Response Project data are ongoing and many research questions remain to be answered. This interim report presents preliminary conclusions which may change as additional episodes are evaluated. To successfully meet the objectives of this project, additional data have been collected and will be used to further evaluate the relationship of wet deposition to stream chemistry and biology in the final report.

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